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Glass—Plant Guide to IDENTIFICATION OF STONES IN GLASS*

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I. Introduction

There is a need in glass-plant laboratories for a complete practical guide to the identification and interpretation of glass stones (crystalline inclusions in glass) encountered in normal plant practice. With adequate equipment, the identification of the common stones when they occur in a reasonably good state of crystalline development can be made a fairly simple matter. In such cases, a complete knowledge of the *theory* of the polarizing microscope and of the behavior of crystals under it is not necessary. It must be kept in mind, however, that stones of very poor crystal development or stones comprised of unusual kinds of crystals cannot be identified in a simple manner. Whenever any stones cannot be readily and definitely identified by the plant operator, they should be submitted for examination to a professional petrographer. It also should be emphasized that microscopic study is but one means of attack on the general problem of the occurrence of stones in glass. The microscope results should be correlated with all other information that may be obtainable from factory practice, chemical analyses, x-ray studies, spectroscopic analyses, etc.

Numerous publications have dealt extensively with the properties of the various minerals that are found in glass stones, and many of these also have considered in detail the relation of stones to factory practice. For the discussion at hand, some of those books and articles have been selected as a reference series (See section VI) covering pertinent techniques, mineral properties, and extensive discussions of the causes and cures for stones in glass. The list is by no means a complete tabulation of the literature, but these selected articles adequately present the needed information. In spite of this abundance of published material, there appears to be no one article that gives for a glass-plant laboratory, a complete guide for the study of glass stones. The present paper, therefore, is an attempt to coordinate, in the briefest possible form, the previously published material for this type of

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work and also to point out what equipment is needed for useful plant practice.

II. Study Suggestions

The identification of stones in glass has become greatly simplified and often consists merely of deciding which of the few minerals that ordinarily occur in glass stones are present in the stones at hand. The determinative tests themselves have been very well established, and, for routine work, only the simpler ones need be considered. The material discussed below will give an adequate basis for such work; as mentioned previously, any unusual problem will probably require the service of a professional petrographer.

(A) *Reading Guide*

As has been discussed, comparatively little attention need be given to complicated optical theory. The refences, (1) and (2) of Section VI (A) discuss the necessary optical theory and experimental techniques, the particular paragraphs to be studied being enumerated in detail. A thorough study of these paragraphs will give an adequate background for routine work. It is true that the other parts of these two books are interesting, and that there are other useful texts on this subject, but a great deal of study, preferably under the guidance of an experienced petrographer, is needed for mastering this other material. Such effort is not warranted for general work in a glass-plant laboratory.

The references under Section VI (B) deal with the characteristics of the glass stones as they occur in commercial practice. Many photomicrographs are given in these references, together with discussions of the origins and interpretations of the various stones. Holland and Preston (10) give especially complete photomicrographs of crystals found in glass stones, and discuss extensively the crystal forms and their development. Fabianic (13) emphasizes, with the aid of numerous photographs of refractories and photomicrographs of glass stones, the relationship of stones to furnace and factory practice. The references of VI (C) relate to various special procedures, and are not especially important in routine work.

(B) *Apparatus and Techniques To Be Studied*

(1) Petrographic Microscope. Properties and use of oculars and objectives, stage, polarizer and analyzer, iris diaphragm, accessories (particularly the first-order red tint plate) and microscope illuminator.

(2) Microscope Mounts of Glass Stones. Examination of stones in the ware, and preparation of thin-section mounts and of powder mounts.

(3) Determinative Properties. (a) General appearance of stone and surrounding glass, (b) Birefringence (double refraction), (c) Refractive index, (d) Sign of elongation, (e) Extinction.

(4) Microscopic Properties of Individual Minerals.

(5) Correlation of Microscope Tests with Other Tests.

(6) Correlation of Properties of Glass Stones with Factory Practice.

(C) *Study of Specimens of Stones*

As soon as enough background has been obtained so that the operator is familiar with the instruments, technique, and terminology, actual study of specimens under the microscope should be started. If possible, this should be done under the guidance of someone who is experienced in this work; much time is saved in this manner and the student is kept on the right track. A selected series of typical specimens is extremely useful for these studies.* The operator can learn from working with such a series just what the various crystals look like, and how to apply the different determinative tests. The experimental work should also emphasize the preparation of specimens, both as thin sections and as powder mounts in liquids of known refractive indices.

III. Experimental Techniques

(A) *General Appearance of the Stones in the Ware*

Even before the pieces of glass containing the stones are removed from the ware, indications as to the type and source of the stones can be obtained from their general appearance and from that of the glass associated with them. The ware should be examined in polarized light as well as in ordinary light in order to check its cordiness. Sometimes individual crystals can be seen under a hand lens in cases of severe devitrification. Dietzel and Springer (9) present a useful tabulation of the relationships between the sources of the stones and their appearance to the naked eye. This significance of the general appearance of stones is outlined by Fabianic (13) who also discusses thoroughly the relation of stones to factory practice.

An idea of the extent of solution of the stones by the surrounding glass can be obtained from the degree to which the stone has been rounded at the edges; this gives an indication of how long the stone has been inactive in the molten glass. This appearance can be influenced also by the original forming conditions of the stone; the more highly developed corundum crystals, for example, have been attributed to sources above the glass line, while the poorly developed ones are said to come from refractory attack below the glass line. The shape can be checked to a certain extent by inspection of the stones as they are found; further information can be obtained during the microscopic examination.

Translucent stones are associated with siliceous sources or with devitrification. Aluminous refractory stones are mostly opaque (except in thin section) and are often yellowish or brownish in color, although small partially-dissolved clay stones can appear quite translucent. Black stones that do not color the surrounding glass can come from chromium oxide or from special steels; black stones that stain the surrounding glass brown or green are usually iron scale from ironwork around the furnace.

Both aluminous refractory stones and siliceous stones often have bulging cords around them, indicating unusually viscous glass at working temperature. Such aluminous areas show very high strains and often show amber tints, while the siliceous ones show low-strain compression cords, and may at times appear bluish in ordinary light.

When glass containing a stone is broken, the cracks tend to pass directly through devitrification stones, while in the case of refractory stones, they tend to pass around

*The minerals listed in the top half of Table I comprise a quite complete list of the minerals found in the commonly occurring stones.

the stone itself. The high strain of aluminous stones sometimes causes spontaneous cracks around the stone. Stones that occur in a shattered condition often indicate undissolved limestone.

(B) *Solubility Tests*

Certain stones can be distinguished by simple tests based on their solubilities. The stones must first be separated as much as possible from the surrounding glass by being crushed or by being drawn out in a flame. Undissolved lime or limestone fragments will react rapidly with hydrochloric acid. Salt cake gall is partially soluble in water. Aluminous and siliceous stones can be differentiated by their solubilities in molten sodium carbonate. The stone is freed from glass and placed in molten sodium carbonate in a platinum crucible. Siliceous stones dissolve rapidly, moving erratically about the melt; aluminous stones persist for a long time.

(C) *Preparation of Stones for Microscopic Study*

It should be emphasized that each particular mineral can occur not only in various sizes and shapes of crystals but also in greatly differing aggregates of these. In each instance, an attempt must be made to discriminate between the basic mineral types that are present. Often crystals can be microscopically examined just as they occur in the glass; this is especially true of those formed by limited amounts of devitrification that result in only a few transparent crystals. Stones that are too massive or too deeply imbedded in the glass to be studied to advantage without preliminary preparation must either be crushed to small fragments (about 100-mesh or 200-mesh size) or be ground thin before they can be studied adequately under the microscope. In any case, if the refractive indices are to be determined the stones must be separated from the glass and broken into fragments.

If only a temporary mount is desired, the crushed fragments are simply mounted in a liquid of known index of refraction (immersion liquid). Where a permanent mount is desired, either the crushed fragments or a thin section through the stone is mounted in Canada balsam or other mounting cement. The thin-section type of mount is particularly valuable when the complete structure of the stone is to be studied.

(1) Powder Mounts. The stone is first separated as completely as possible from the glass. Sometimes the stone is crushed and the glass and crystal fragments separated with tweezers or a probe (a low-power binocular microscope is useful for this work). In other instances, the glass around the stone is drawn, in a flame, into a thin fiber, and the stone is then broken from the fiber.* (Small Pyrexbrand rods or platinum-tipped tongs can be used as "handles" for this drawing process.)

After the fragments of the stone have been separated from the glass, they can be crushed under acetone (to prevent scattering of the fragments during the crushing) in a small agate mortar, or they can be crushed between two small steel blocks, each having a polished face. These processes should consist of crushing rather than grinding. In the first method, the acetone can be poured off with a rotating and tilting motion that leaves the fragments in the mortar, where they dry very quickly. The particle size can be controlled by the extent of the crushing; some petrographers use a small, 100-mesh sieve to eliminate larger particles.

(a) Temporary powder mounts: When only a temporary mount is desired, a drop of an immersion liquid having an intermediate index is placed by means of the applicator rod on a clean microscope slide that has been wiped dust-free with a chamois.** (Dust and line will show as curled threads of very high birefringence under the microscope.) A very little of the powdered sample is sprinkled onto the drop by means of a small knife blade, or a small spatula formed from the end of a paper clip by hammering. The cover glass, ⅜-in. to ½-in. wide, is then placed upon the liquid and the powder. (The cover glasses can be ½-in. squares or circles, or can be pieces of ¾-in. glasses cut into quarters by means of a diamond pencil.) The slides should be labeled either with a wax pencil or with pen and ink.

Precaution: The immersion liquids must be kept absolutely clean at all times. The drops of liquid should be added to the microscope slides only at points free from powder and from other liquids.

(b) Permanent powder mounts: Permanent mounts are prepared with Canada balsam or some synthetic cement such as glycol phthalate or cumarene-indene resin; the cement is used to imbed the powder and to cement the cover glass on the microscope slide. For these mounts balsam is first cooked, with stirring, on the microscope slide over a hotplate at about 100 to 150°C. The balsam is ready for use when a bit of it, cooled on the tip of a steel probe, can be easily flicked from the probe with the thumbnail. The balsam should not be darkened appreciably by this heating. It should not be brittle upon cooling, but if it is too soft it is liable to pick up abrasive grains during subsequent grindings. Usually, several slides are prepared at the same time.

A very little of the powdered sample is distributed evenly over the cool balsam on a prepared slide, and the whole is heated until the balsam becomes soft. A cover glass is then added with one side being lowered first so as to sweep out entrapped air. The slide is removed to a steel plate to cool, the cover glass being pressed down firmly during the cooling by means of a small cork. When the slide is cold, the excess balsam outside the cover glass can be trimmed off with a razor blade. The slide is then wiped clean with acetone or xylene, and an appropriate label applied.

(2) Thin-Section Mounts. When the structure of the stone is important, a thin-section mount can be prepared to show the relationships of the various individual crystals. Such a mount consists of a thin section of the glass stone cemented onto a microscope slide with a cover glass protecting the upper surface. For the present work, the sections do not need to be of any standard thickness, the particular thickness in any case being governed by the crystals in the stone. If there is no particular hurry and simply a permanent record of some special stone is desired, it is usually preferable that the specimen be sent to a professional maker of thin sections.†

If the mount is to be prepared in the laboratory, the

*This method has been described by Zarbo, Hunt and Smith (18) for the separation of inhomogeneities for purposes of chemical analysis; chemical procedures are given by them for these semi-microanalyses.

**A more involved technique allowing the use of successive index liquids in a single mount has been described; see H. W. Fairbairn, (17).

†For example, such work is done by: 1) W. Harold Tomlinson, 260 N. Rolling Road, Springfield, Pennsylvania. 2) George S. Rev, Microscopic Thin Section Laboratory, Schermerhorn Hall, Room 108, Amsterdam Ave. at 119th St., New York, N. Y.

TABLE I.
PROPERTIES OF MINERALS FOUND IN STONES OCCURRING IN COMMERCIAL GLASSES

No.	1 Name and Composition	2 Crystal System	3 Optical Character	4 Index of Refraction	5 Birefringence	6 Sign of Elongation	7 Extinction
(1)	Tridymite (Low) SiO_2	Orthorhombic	Biaxial (+) (Almost uniaxial)	$\alpha = 1.469$ $\beta = 1.47$ $\gamma = 1.473$	Weak 0.004	(—)	Parallel
(2)	Cristobalite (Low) SiO_2	Tetragonal (Pseudo-isometric)	Uniaxial (—)	$\epsilon = 1.484$ $\omega = 1.487$	Very weak 0.003	(+)	Parallel
(3)	Typical Soda-Lime-Silica Glass	None	Isotropic	$\eta = 1.51$	None	None	Complete
(4)	Carnegieite $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$	Triclinic	Biaxial (—)	$\alpha = 1.509$ $\beta = 1.514$ $\gamma = 1.514$	Weak 0.005	No marked elongation	
(5)	Canada Balsam	None	Isotropic	$\eta = 1.537$	None	None	Complete
(6)	Nephelite $NaAlSiO_4$ or $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$	Hexagonal	Uniaxial (—)	$\epsilon = 1.536$ $\omega = 1.540$	Weak 0.004	(—)	Parallel in needles
(7)	Low Quartz SiO_2	Hexagonal	Uniaxial (+)	$\omega = 1.544$ $\epsilon = 1.553$	Weak 0.009	None	No cleavage or elongation
(8)	Devitrite $Na_2O \cdot 3CaO \cdot 6SiO_2$	Orthorhombic	Biaxial (+)	$\alpha = 1.564$ $\beta = 1.570$ $\gamma = 1.579$	Moderate 0.015	(+)	Parallel in needles
(9)	(α) Pseudowollastonite $CaO \cdot SiO_2$	Probably Monoclinic	Biaxial (+) (Almost uniaxial)	$\alpha = 1.610$ $\beta = 1.611$ $\gamma = 1.654$	Very strong 0.044	(—)	Parallel or inclined
(10)	β-Wollastonite $CaO \cdot SiO_2$	Monoclinic	Biaxial (—)	$\alpha = 1.616$ $\beta = 1.629$ $\gamma = 1.631$	Moderate 0.015	(+) or (—)	Parallel or inclined
(11)	Mullite $3Al_2O_3 \cdot 2SiO_2$	Orthorhombic	Biaxial (+)	$\alpha = 1.642$ $\beta = 1.644$ $\gamma = 1.654$	Moderate 0.012	(+)	Parallel
(12)	Diopside $CaO \cdot MgO \cdot 2SiO_2$	Monoclinic	Biaxial (—)	$\alpha = 1.66$ $\beta = 1.67$ $\gamma = 1.69$	Strong 0.030	(+)	Symmetrical or inclined, 37° to 44°
(13)	Corundum α-Al_2O_3	Hexagonal-Rhombohedral	Uniaxial (—)	$\epsilon = 1.759$ $\omega = 1.767$	Weak 0.008	On edge (+)	Parallel to crystal outlines
(14)	Zircon $ZrO_2 \cdot SiO_2$	Tetragonal	Uniaxial (+)	$\omega = 1.93$ $\epsilon = 1.99$	Extreme 0.060		Parallel
(15)	Undissolved Clay						
(16)	Sodium Disilicate $Na_2O \cdot 2SiO_2$	Orthorhombic	Biaxial (—)	$\alpha = 1.497$ $\gamma = 1.508$	Moderate 0.011		Parallel
(17)	Sodium Metasilicate $Na_2O \cdot SiO_2$	Orthorhombic	Biaxial (—)	$\alpha = 1.513$ $\gamma = 1.528$	Moderate 0.015		Parallel
(18)	Albite $Na_2O \cdot Al_2O_3 \cdot 6SiO_2$	Triclinic	Biaxial (+)	$\alpha = 1.528$ $\beta = 1.532$ $\gamma = 1.538$	Moderate 0.010		Inclined, 12° to 19°
(19)	$2Na_2O \cdot CaO \cdot 3SiO_2$	Isometric	Isotropic	$\eta = 1.571$	None		Parallel
(20)	Anorthite $CaO \cdot Al_2O_3 \cdot 2SiO_2$	Triclinic	Biaxial (—)	$\alpha = 1.573$ $\beta = 1.579$ $\gamma = 1.586$	Moderate 0.013		Inclined, 51° to 70°
(21)	Barium Disilicate $Ba_2O \cdot 2SiO_2$	Orthorhombic	Biaxial (—)	$\alpha = 1.598$ $\gamma = 1.620$	Rather strong 0.022	(—)	Parallel
(22)	Andalusite $Al_2O_3 \cdot SiO_2$	Orthorhombic	Biaxial (—)	$\alpha = 1.634$ $\beta = 1.638$ $\gamma = 1.643$	Moderate 0.011	(—)	Parallel or symmetrical
(23)	Sillimanite $Al_2O_3 \cdot SiO_2$	Orthorhombic	Biaxial (+)	$\alpha = 1.659$ $\beta = 1.661$ $\gamma = 1.680$	Rather strong 0.021	(+)	Parallel
(24)	Kyanite $Al_2O_3 \cdot SiO_2$	Triclinic	Biaxial (—)	$\alpha = 1.712$ $\beta = 1.720$ $\gamma = 1.728$	Moderate 0.016	(+)	Inclined, up to 30°

TABLE I. (Continued)

No.	8 *Occurrence in Glass Stones*	9 *Appearance Under Microscope*	10 *Distinguishing Properties*
(1)	Batch stones (sand). Silica drip from crown. Devitrification. Silica scum.	Wedge-shaped twins from quartz inversion. Hexagonal plates from devitrification, seen on edge as needles and laths. Anhedral forms. Pine-tree growths with 60° angles.	Low index. Negative elongation. Wedge-shaped twins (if present) with two-stage extinction. 60° pine-tree growths.
(2)	Devitrification. Silica scum. Altered quartz. Crown drip.	Pine-tree growths, usually with 90° angles; skeleton crystals. Needles show (+) elongation. Extremely weak birefringence (due to twinning).	Low index. Pine-tree growths. Positive elongation in needles. Index > 1.480; tridymite < 1.480.
(3)		Black under crossed nicols, when unstrained.	
(4)	High temp. form of nephelite. (Artificial mineral only.)	Multiple twinning (alternate bright and dark lamellae under crossed nicols).	Lamellar twins. Index.
(5)	(Cement for microscope slides.)	(No birefringence or interference figure.)	
(6)	Soda-glass or vapor attack on alumino-silicate refractories. "Worms" from glass line.	Needles. Clusters of patches showing extinction at various angles, reds and blues with tint plate, and low relief in balsam. Brownish worms showing appreciable relief in balsam.	From mullite by negative elongation, low relief in balsam. Often associated with corundum and mullite. Brownish worms.
(7)	Batch stones. (Rarely, from silica brick.)	Low relief. Irregular grains. No cleavage. Varied colors with tint plate. (Tridymite fringes.)	General appearance. Index. Low relief.
(8)	Devitrification of soda-lime silica glasses. (Artificial mineral only.)	Fan-shaped radiolites. Prismatic needles with positive elongation. Often associated with wollastonite or with tridymite.	Feathery structure. Index and sign of elongation.
(9)	Thermodynamically stable form of $CaO \cdot SiO_2$ above 1180°C. Glass devitrification.	Hexagonal plates of extremely low birefringence, laths and needles with negative elongation and high birefringence.	From β form by sign of elongation. From tridymite and corundum by indices.
(10)	Stable form of $CaO \cdot SiO_2$ below 1180°C. Devitrification. Often associated with devitrite.	Prisms; needles and short laths with positive elongation and low birefringence. Radiating feathery or spherulitic aggregates.	From α form by sign of elongation and habit. Usually parallel extinction on laths.
(11)	Soda-glass attack on alumino-silicate refractories. Inversion of sillimanite refractories.	Needles or laths of good relief and moderate birefringence showing positive elongation, and slight pleochroism when from molten-cast blocks.	From nephelite by sign of elongation. Often occurs with corundum and nephelite.
(12)	Devitrification of dolomitic glasses (may require only small percentage of magnesia).	Grains of 4 or 8 sides with fairly high relief and strong birefringence. Laths show inclined extinction.	Subhedral grains and laths showing inclined extinction and high birefringence.
(13)	Glass attack on aluminous refractories and alumino-silicate refractories.	High-index hexagonal plates when seen on edge show abnormally high birefringence and (+) elongation. May be green from Cr_2O_3. Perfect, unetched grains are from melt; etched, irregular ones with inclusions are from molten-cast refractory.	High index. Hexagonal shape. Occurs often with mullite and nephelite.
(14)	Attack on ZrO_2 refractories, followed by devitrification.	Extremely high index and birefringence. Wormy blobs. Fine pine-tree growths.	Extremely high index and colors are characteristic.
(15)	Attack on clay refractories.	Globular semiopaque mass, often fringed with corundum, mullite and nephelite.	Rounded semiopaque mass with crystal fringes.
(16)	Devitrification of soda-lime-silica glasses.	Needles.	Indices and moderate birefringence.
(17)	Devitrification of soda-lime-silica glasses.	Plates and needles.	Indices and moderate birefringence.
(18)	Undissolved feldspar from batch.	Multiple (polysynthetic) twinning. Cleavages in three directions. (See anorthite.)	Twinning. Lower index and extinction angles than anorthite.
(19)	Devitrification.	No birefringence. Octahedra.	No birefringence. Index.
(20)	Undissolved feldspar from batch.	Twinning similar to albite but with different extinction angles for the lamellae.	Twinning. Higher index and extinction angles than albite.
(21)	Devitrification of BaO-bearing glasses, e.g., barium crowns.	Fringed diamond-shaped crystals. Radiating fibrous spherulites. Doughnut-like feathery aggregates.	Birefringence, index and sign of elongation.
(22)	Attack on andalusite refractories. Contaminated glass sands.	Tablets or grains with rounded edges. Some fringes of nephelite. Some inversion to mullite. Negative elongation.	From mullite by sign of elongation. (See next entries.)
(23)	Attack on sillimanite refractories. Contaminated glass sands.	Nephelite fringes or mullite as with andalusite. Parallel extinction and positive elongation.	From andalusite by birefringence, index and sign of elongation.
(24)	Attack on kyanite and sillimanite refractories. Contaminated glass sands.	Nephelite or mullite as above. Inclined extinction. Higher index than above two.	From andalusite, sillimanite and mullite by extinction and index.

stone is cut from the ware together with about a square inch of the imbedding glass. One face of the sample is ground away enough to cut into the stone, and this face is then ground smooth with finer abrasive. This grinding is best done on two horizontal lap wheels; one is used only for the first, coarse grinding (with No. 120 carborundum) and the second for the fine grinding (with No. 240 or FF carborundum). Special care must be taken not to transfer any of the coarse abrasive to the fine wheel. The grinding can be done on stationary plates but this is very tedious. Adequate water must be used during all grinding; it can be splashed onto the wheels from an erlenmeyer flask fitted with a one-holed stopper bearing a glass tube, or can be delivered from a reservoir by a syphon system. The sample is then washed, dried, and mounted upon a microscope slide with cooked Canada balsam. To do this both the ground sample and the balsam slide are heated on the hotplate; the ground face is placed on the molten balsam, in such a way that air bubbles are swept out from under it, and the mount is cooled on a steel plate. The sample is pressed quite tightly to the slide during the cooling.

The second face is now ground until approximately the desired thickness is obtained, that is, until the desired properties can be seen under the microscope, the appearance of the specimen being checked periodically during the grinding. For this checking, the top of the specimen can be covered with a cover glass and wetted with an immersion liquid of 1.51 index of refraction. The final stages of the grinding must be done with great care, since the thin specimen can very easily be destroyed. The final grinding is often done on a stationary glass plate with a "figure-eight" type of motion and with 600-mesh alumina or carborundum as the abrasive.

When the desired thickness has been obtained (this thickness is, in most cases, considerably greater than the standard 0.001-inch thickness recommended for rock sections), the mount is heated; some cooked balsam is added to the top of the specimen, and a cover glass is applied as described in part (b) above. The mount should be free from air bubbles both below and above the specimen; should many be present after the cementing of the sample or of the cover glass, the slide can be rewarmed and the bubbles squeezed out with pressure from the cork. The mount is then cleaned and labeled as previously described.

(D) *Microscopic Determinative Properties*

As is discussed in the Introduction, the identification of crystals in glass stones is a matter of determining which of the possible types of minerals are present in any particular case. The properties that permit this differentiation between the kinds of crystals are tabulated for most glass-stone minerals in Table I of this report. The most pertinent properties are listed in Columns 4 through 10; these properties and their determination are discussed below.

(1) Birefringence or Double Refraction. Homogeneous, unstrained glass has but one index of refraction (for a given wavelength of light) and appears black in the microscope when the polarizer and analyzer are at the extinction positions (crossed nicols). If the glass is strained, it no longer is black in these circumstances but shows bright, and may exhibit colors if the strain is high enough and the specimen thick enough. Most of the minerals that occur in glass stones also show bright under crossed nicols; this is not due, normally, to strain in the crystals however, but is a natural property caused by their having different refractive indices in different directions in the crystals. This property of crystals* and strained glass is termed *birefringence* or *double refraction*. In the present work, birefringence will be considered as indicated simply by the brightness of the mineral fragments under crossed nicols. In a powder or thin-section mount a great variety of fragments are represented, and a general estimate of the birefringence can be made; in any particular mount, those individual crystals exhibiting the greatest brilliance under crossed nicols are most significant for this purpose. A mineral of strong birefringence, for example, will show brighter in general than one of low birefringence.

Birefringence is useful also when the fragments in a mount are being examined for the presence of crystals. Both the crystals and the glass can be seen under crossed nicols with the red tint plate inserted. Another procedure is to rotate the analyzer about 3° from its extinction position; here again, the crystals and glass are visible together and are distinct from each other. These techniques are especially applicable when immersion oils near to the solids in index are being used.

(2) Index of Refraction. Measurements of refractive indices are made on crushed materials, prepared as discussed previously under Temporary Powder Mounts, and are equally applicable to crystals and to glasses. Usually, only a representative index range need be found for any particular crystal type; it is not necessary to identify the principal (crystallographic) indices. As indicated in Table I, there is but little overlapping in refractive index between the commonly occurring minerals (those above the division line). Each glass has only one index of refraction if it is not strained.

(a) Immersion Liquids: For index of refraction determinations on fragments of crystals or glasses, a set of calibrated immersion liquids of known indices is used. Such sets are obtainable in a wide variety of specifications; for the work at hand a set ranging in index from about 1.41 to about 1.78 in steps of 0.01 between liquids is satisfactory. A mixture of equal quantities (usually one drop of each) of two adjacent liquids of such a set gives a new liquid with an index about half way between those of the original pair; hence, the intervals of the set described can be reduced to about 0.005. Great care must be exercised at all times to keep the liquids completely free from contamination by foreign material, and they should be kept away from light as much as possible, being stored in a covered box. Special refinements such as corrections for the variation with temperature of the indices of the liquids do not need to be made in the type of work under discussion.

(*Continued on page* 90)

*There are certain exceptions to the occurrence of birefringence as discussed above that should be mentioned so as to avoid confusion when they are encountered. Any mineral crystallizing in the isometric (cubic) system has only one index of refraction and therefore does not exhibit birefringence; however, the compound $2Na_2O \cdot CaO \cdot 3SiO_2$ is the only isotropic mineral listed among those usually found in glass stones. Since the two extreme indices of refraction of cristobalite are very near together, cristobalite has very weak birefringence; this property combined with twinning in the crystals makes cristobalite appear almost isotropic in thin fragments. A second type of exception is that certain crystals have an orientation in which they are not birefringent. In a thin section of quartz grains, for example, some grains may appear isotropic. Other fragments in the mount of such a mineral, however, will not have this particular orientation, so the mineral's birefringence will be obtainable from these.

GAS HEAT SPEEDS PRODUCTION OF ELECTRON TUBES

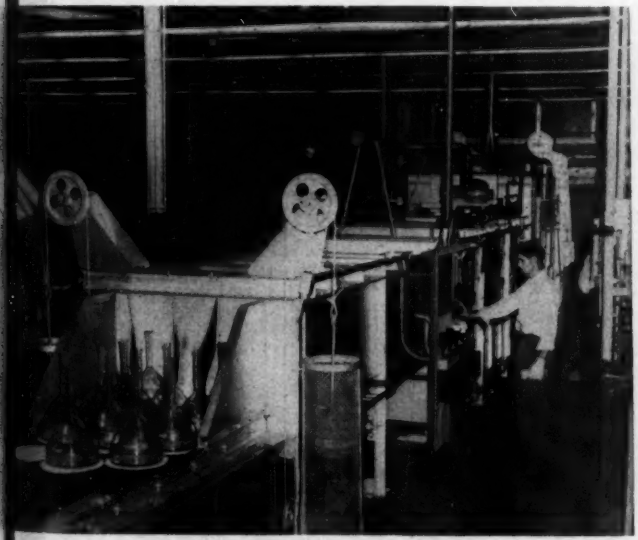
Nearly seventy-five years ago an obscure telegraph operator named W. Smith discovered the light-sensitive properties of selenium which indicated that light values could be converted into equivalent electrical values. Through the years that followed, much experimentation was done in changing light rays into electrical impulses, and electrical impulses back into light rays. The ultimate result of all this investigation has been what today is known as television.

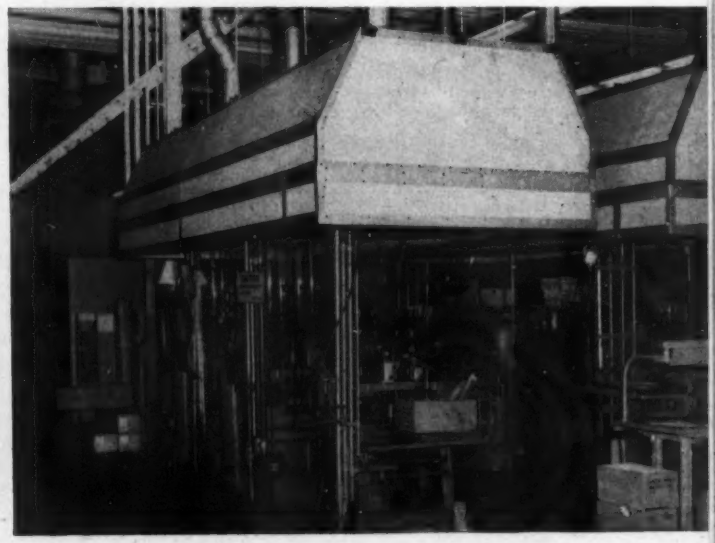
As pioneers in the field of electron tubes, the Radio Corporation of America has developed a series of television tubes to the point where this new phase of the radio industry is now ready for home use. The heart of television is the iconoscope which is the tube that picks up the image or scene of action that is to be televised and translates the reflected light into electrical impulses, and the kinescope through which the televised radio signals are translated back into light to form an image or picture on the sensitive face of the kinescope.

The perfection of the modern home television receiver is due in a large measure to intensive research and development of allied electronic devices during the war which gave us radar, shoran, loran, airborne television, the snooperscope and the sniperscope. With this experience, the RCA Tube Department has gone into volume production of television tubes, in addition to their regular improved line of transmitting and radio receiving tubes.

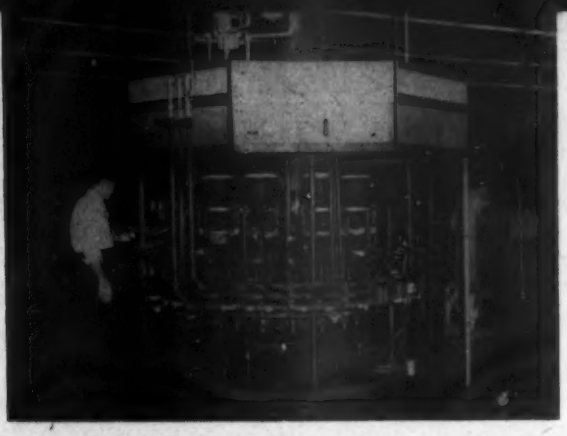
In a new plant at Lancaster, Pennsylvania, which was built during the war for production of electron tubes for our armed forces, the production of many types of television tubes is going forward by leaps and bounds on new automatic machinery that has been developed to handle the many glass operations. From the small kinescope picture tubes that produce an exceptionally brilliant image which is optically enlarged for projection on a viewing screen, to the largest kinescopes which have a ten inch face on which the image is viewed directly, there are many precise and intricate operations on both the tube elements and the glass bulbs themselves. The plant is fully air-conditioned, and the humidity level is maintained at a steady level to guard against any harmful effects on the sensitive elements through handling by many skilled operators.

One of the first glass operations is to make the flare of the stem which holds the elements. This is done on the flare machine in which G12 glass tubing is cut off and pre-formed for a flat pressed stem. Here gas fuel is used to heat the glass parts in various stages to temperatures from 600° C. to 900° C. as they index around the automatic machine. Varying flame patterns are formed by special burners to heat local portions of the

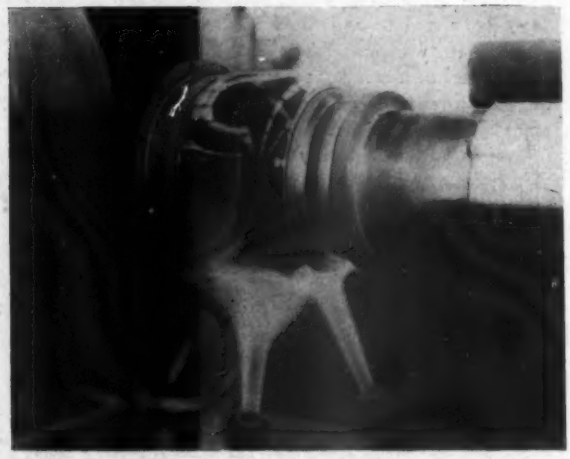




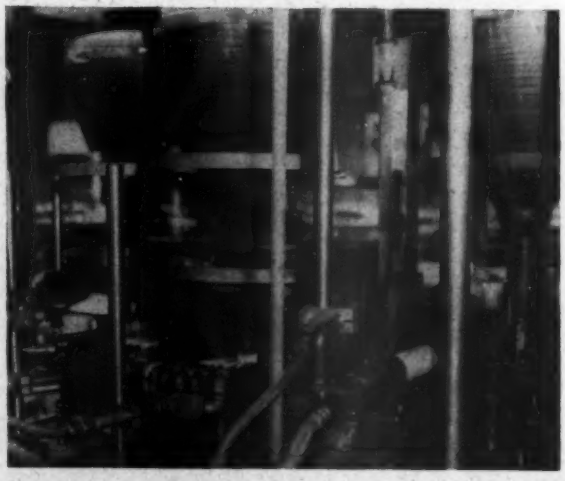
Left, in the production of Kinescopes, the RCA television reproducing tubes, the first operation on the blanks is to hermetically seal a contact button in the tapered section of the bulb. They are then annealed in this continuous gas-fired radiant tube glass lehr at 450°C. where the cycle of passing through the heated air is from 4 to 6 hours depending on the size of the tube. Right, Battery of automatic flare machines which make the glass stems for radio tubes, in which the tube element supporting and lead-in wires are sealed. Specially designed gas burners emitting predetermined flame patterns heat the glass tubing to various stages of viscosity in order that it may be flat pressed into a stem. All equipment in this plant utilizing heat in any form for processing is efficiently hooded and ventilated to carry off heat and products of combustion so as not to throw the air conditioning off balance.



In this completely automatic machine for sealing 10" Kinescopes, the elements are set in the tube, the flare and bulb are sealed and the cullet cut off. These operations take place as the tubes index around the machine to their respective stations where varying patterns of gas flames perform the successive operations on the glass. It will be noted that a hood covers the entire machine to draw off heat and products of combustion.



A long, low temperature gas flame is used to anneal this 100 KW transmitting tube of 7052 glass after the metal rings have been sealed onto the glass.



Six needle gas flames concentrate on the bulb neck where the cullet is cut off as the tube revolves in the flame. The large gas burner at the right performs an annealing operation.

glass part and to control the viscosity of the glass for forming. When this part has been formed, the lead-in wires to the tube elements are inserted and the assembled element units are placed on another automatic gas-fired machine where special flame patterns heat those parts of the stem to just the proper temperature and for just the correct time to effectively seal the wires into the glass stem. Annealing takes place immediately after the part has reached the last position on the machine. It is then ready for mounting the tube electrodes after which it is ready to be sealed into the bulb blank.

The bulb or kinescope blanks are subjected to many processes and operations, the first being a thorough washing inside and out after which they are placed in specially constructed racks in the settling room. This room is constructed on its own foundation and the floor is composed of a heavy concrete slab floating on a layer of cork. There is no physical connection to any other part of the building so as to eliminate any possible transmission of vibration. A measured quantity of liquid containing a fluorescent substance is placed in each tube. Slowly the solid active fluorescent material settles on the inside of the tube face to form the scanning screen on which the electrons react to produce the image. When the settling is complete the remaining liquid is carefully decanted off.

The next step is to insert a "button" in the side of the bulb by means of a gas-fired torch. The operator softens the glass, punctures a small hole, and inserts the "button" or electrical contact which is hermetically sealed in. After the button is inserted the tubes must be annealed. They are placed in a continuous gas-fired radiant heated lehr where heated air at 450° C. properly anneals the 10" kinescope tubes during a 4 hour cycle.

The inside of the bulb is next coated with a colloidal graphite mixture which serves the purpose of carrying off the electron charges after they bounce from the screen. The ground electrical circuit is through the "button" previously inserted. To thoroughly bake on

After a small section has been cut off a glass tube and the end flared, bottom portion is heated by a special gas flame pattern which places the heat exactly where it is wanted at the proper temperature for flat pressing. Heating time is controlled by the speed at which the machine indexes from station to station. The gas flame temperatures vary at the different stations from 600° to 900° C. on this G 12 glass depending on the particular operation.

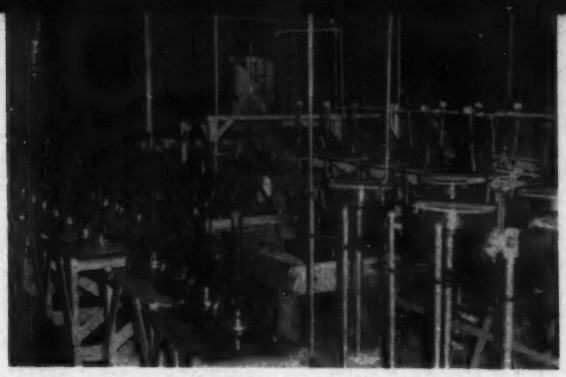
this inner graphite coating the tubes are placed in a continuous gas-fired oven at 400° C. for a one and one-half hour baking cycle.

At this stage of manufacture the prepared bulb is ready to be sealed to the glass stem which supports the internal elements, or electron gun, and contains no exhaust tube. This operation takes place on a fully automatic gas-fired sealing machine where at the different stations, as the tube indexes around, the varied flame patterns of the different burner tips perform their heating operations with precision. At the final station the excess neck of the bulb, or cullet, is cut off when the No. 6 Lime glass of which the kinescope blanks are made is heated to 1050° C. by a needle flame which makes a clean sharp cut.

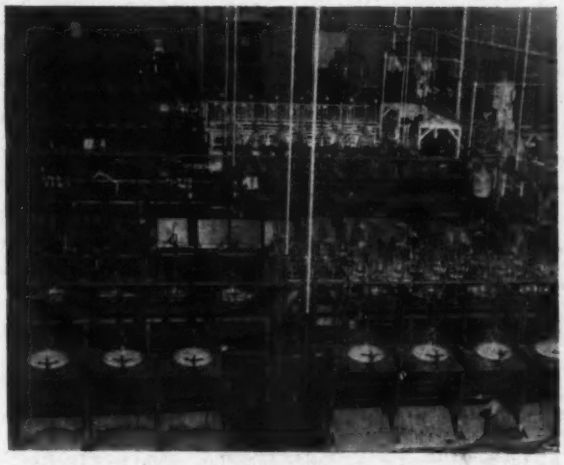
After sealing, the tube progresses to an exhaust machine where an extremely high vacuum is developed. While on this machine, the glass bulb is heated by radiant heaters, namely, to its softening point to assist the vacuum pump in removing occluded moisture and gases. The electron gun and other internal elements are heated by high-frequency induction methods and at another stage of the process working voltages are applied to the tube elements themselves. When the vacuum process has reached its final position the tube is "tipped off," an operation which seals the tube permanently and severs the connection to the vacuum pump.

Following this is a series of operations involving the affixing of the base, seasoning, electrical testing, quality check and finally packing. The kinescope is then ready to be sent on its way to the customer.

Throughout the entire glass operations, gas fuel is the heat which provides the exacting temperatures in varied flame patterns measured in fractions of an inch to accomplish operations demanding close tolerances of time and temperature and accurate control of dimensions. It is a tribute to the ingenuity of gas engineers and machine designers that these relatively high temperatures can be used effectively in such narrow confines.

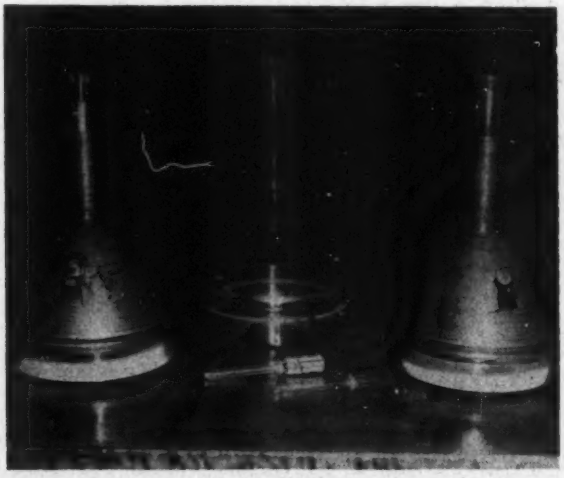


Preparing 10" Kinescope bulbs for application of the fluorescent coating to the inner force.



The fluorescent coating on the inside face of the Kinescope bulbs is applied in this settling room. The coating in suspension is put into the bulbs and the fluorescent particles gradually settle out forming the coating upon which the image is made visible. The excess liquid is decanted off. This special room in the Lancaster plant, is so constructed on a cork foundation that no vibration can be transmitted from other parts of the building or the surrounding countryside to the settling racks.

In order to carry off the electrons after they have produced an image on the fluorescent screen, a colloidal graphite coating is applied to the inside of the tube which makes an electrical contact with the sealed-in button. To bake on this coating the bulbs are placed in a gas-fired rotary bake oven at 400° C. for a cycle of approximately 1½ hours.



The RCA 10" Kinescope. In the center is a bulb blank in which the "button" has already been sealed. In front of this bulb are the stem and completed tube element assembly. The right hand bulb shows the fluorescent coating as well as the colloidal graphite lining. A finished Kinescope may be seen at the left complete with base, ready for use.

GLASSWARE INDUSTRY DISPUTES ILL-TIMED ACTION ON RECIPROCAL TRADE AGREEMENTS

H. L. Dillingham submits brief to the Committee for Reciprocity Information for American Glassware Association. W. L. Orme and C. W. Carlson present oral arguments in behalf of industry and American labor standards. Bernard M. Baruch backs general policy.

In connection with the proposed trade agreements with Czechoslovakia and seventeen other foreign countries, the American Glassware Association has, on behalf of its members and the rest of the industry, filed a 10,000-word statement for the guidance of the Committee for Reciprocity Information.

This statement "comments on and augments" certain data which was supplied to the Committee by the Tariff Commission,—data which, according to Herman L. Dillingham, Secretary of the Association's Tariff Committee, "would be considered as correct unless other views were presented by the industry."

The data applies to classifications in the Tariff Act of 1930 in par. 218 (2), (b), (c), (d), (e), (f), (g), and 230 (d).

In the introduction to the statement, the Association points out the military importance of the hand-made glass industry, as evidenced during World War II:

"Now that hostilities have ceased we are in a position to announce the important part which this section of the glassware industry, not including flat, plate, and building glass and food containers and bottles, had in producing the necessary technical equipment with which the Allied Armed Forces had to be supplied.

"The technical departments of Army and Navy will testify to the importance of this glassware in the conduct of the war. Communication equipment included radio and power tubes; fire control and range finding were supplied and radar tubes and numerous other small glass parts. Electronics were most essential in this war and they would have been helpless without battery jars, insulators and a host of specially designed glass parts. Navy, Merchant Marine and Army Transport were supplied running lights, lenses of every description, steam-tight globes and numerous other harbor lighting and signaling ware. The Army and Air Corps were destitute in the beginning of the war for searchlight reflectors, signal lamps, magnifying and projection lenses, as well as thousands of needed automotive lenses and tank equipment, artillery range finding equipment was in constant demand from the very beginning of hostilities.

"Army and Navy medical departments bought laboratory and hospital supplies made of glass, and continually requested new apparatus which, they said, was more important than bullets; industrial laboratories were always calling for more customary equipment. The glass industry of this section supplied all of it.

"The Procurement Divisions of the Armed Forces continually called for new and more equipment. Fortunately the glass industry had the engineering, technical and laboratory personnel to produce the specifications for this required equipment but often there was a scarcity of skilled glass workers to produce the needed volume. The trained personnel which was available came from the factories that had been producing tableware, tumblers, illuminating glassware and scientific ware for the consumer market prior to the war. Had this personnel not been at hand it would have taken many years to have trained workers to manufacture to the exacting specifications required for the war. This supply of skilled employees was made possible only because the U. S. market had consumed large quantities of household and scientific ware."

Therefore the Association's statement recommends that the wages of low-paid European workers be equalized with the higher wages here. But, since the labor market in Europe is at present so confused and stable, the Association advises postponing all action on tariff rates for the time being.

Furthermore, in view of the fact that the Czech glass industry is now nationalized, the Association deprecates the situation in which manufacturers in this country are "facing a devastating competition with a nationalized industry which already has a distinct advantage in labor production costs and now seeks a U. S. tariff reduction, On the one hand our government gets lip service from I. T. O. principals of no subsidies, no behind the scene cartels, no other barriers, while actually in the glass industry already we are told that export prices are fixed, production allotted, and operational regulations agreed upon."

Some of the highlights from the Association's specific amplifications and comment on individual rate classifications and Tariff Commission data appertaining thereto are as follows:

Pat. No. 218 (b) Czechoslovakia Fusible Enamel Rods and Canes . . . Wholly or in Chief Value of Glass. Fusible enamel, rod and cane is not a designation used in the glass trade. It is evident that the concession being considered applies to fusible glass as a material in rod or cane form. . . . Since the language governing the classification of rods and canes was written in the Tariff Act of 1930 there has been litigation in the Customs Courts which has been helpful in defining the scope of this provision. These precedents should be retained if the committee considers a concession on fusible enamel glass. In order that this type of glass in rod or cane form be included, we suggest the use of the following language:

"Unfinished fusible glass enamel cane and rod, three-eighths of an inch or less in diameter, of opaque glass containing not less than twenty percent lead; Provided, that none of the foregoing shall be wholly or in part ground, sand blasted, polished, pressed, tooled, molded, or decorated in any manner."

Par. No. 218 (b) Czechoslovakia. Glass Tubes, Tubing, Rods, and Canes (Except Fusible Enamel Rods and Canes and Guage Glass Tubes). Although classified for tariff

purposes with ordinary bottles and jars blown in molds from molten glass annealed and packed directly from lehrs, vials and ampoules are containers fabricated from glass tubing and are distinctive both by process of manufacture and by use. The fabrication of vials and ampoules requires numerous operations, not necessary in producing bottles and jars. A large proportion of vials and practically all ampoules are used as containers for packaging serums, antitoxins, pharmaceutical and biological products. These vials and ampoules require a chemical-resistant glass of low solubility. The production of this glass and the containers is extremely important to the public health and the medical departments of the Army and Navy. This division of the industry is considered "critical" by the War Department.

Up to the beginning of the First World War, alkali-free tube and ampoules, along with laboratory glassware, optical, scientific and surgical instruments were completely dominated by Germany; in fact, they had a world wide government sponsored and, in the case of Schott & Jenosen and Royal Berlin chemical porcelain, a government subsidized monopoly.

Par. No. 218 (c). Illuminating Glassware. In a magazine just published, *The Czechoslovak Glass Review*, September 1946, an entire article is devoted to the preparation which manufacturers in that country are now making to enter the illuminating glassware markets of the world. Quoting from that article:

"... a glass at the price of goods calculated Ex Works shows that no glass works throughout the world could manufacture illuminating glassware at such low prices. If we take the very considerable costs of packing, which are an obviously large item in the cost of illuminating glass, and add the exorbitantly high freights, the prices of Czechoslovak illuminating glass are always much lower than the average prices of illuminating glass in the world markets."

It is this competition which the American industry must face and because of the high wage scales in this country it will be impossible for the industry to secure any export business of any amount and the inroads that would be made in the U. S. markets will gradually force U. S. illuminating glass manufacturing industries out of the hand illuminating glassware business. To lower tariff at this time on this business is unsound. The injury will be to small factories located in small communities and the impact of no employment will be keenly felt in these localities.

Par. No. 218 (c) Czechoslovakia. Illuminating Glassware: Chimneys. It is true that exports normally exceed imports. That is because our price is right and sometimes lower than or at least meets Central European prices in the normal world market. The low price is the result of the relatively large volume of sales of this article in the U. S. If the U. S. home market is invaded by foreigners through cutting of our tariffs we shall eventually be deprived of our export trade of chimneys and lantern globes. It therefore seems a sound policy to continue the tariff rate as is on these articles. Sharing this market is unsound for we shall give away finally not only our export business but our domestic business and end up by making almost no chimneys and lantern globes, and there will be another group of workers unemployed in a business in which they are skilled.

Par. No. 218 (c) Czechoslovakia. Illuminating Glassware: Globes and Shades. The Czech agreement in which tariff rates on this ware were reduced lasted for only one year, April to April 1938-9. The treaty was suspended and during that period quantities of Czechoslovakian illuminating ware began to appear in the U. S. market. During that period, however, U. S. importers were hesitant to place orders because of the impending political crises in Europe. U. S. manufacturers during that period began to eliminate the so-called stock household and commercial lines because they could not compete with them. That volume was missed but it did not last long enough to seriously upset the industry. To reestablish these Czech tariff reductions at this time would result in the gradual elimination of a very important part of the illuminating glassware industry which manufactures globes, shades and reflectors for household and commercial use. It would start with the importation of an inexpensive line which would fast push upward into the more decorative lines because of the low wage rates which prevail in Central Europe.

Par. No. 218 (c) Czechoslovakia. Illuminating Glassware: Prisms, Chandeliers, Wall Brackets, Candelabras, Etc. Any change in tariff rates downward will to a large degree eliminate the manufacture of the pressed non-polished prism made in this country and will cast aside any probability of ever trying to develop mass production methods to cut and polish it because it will seem hopeless to try to do it while the existing high U. S. labor rates prevail. Were the tariff rates continued at their present levels it is not improbable to forecast that eventually some method would be devised which would produce these items competitively in spite of the low labor rates and cottage production practices of Central Europe which is the recognized source now for procurement of these articles.

Par. No. 218 (c) Czechoslovakia. Illuminating Glassware: "All Other." If tariff rates are cut on this ware, it will mean that U. S. producers will have to drop these lines which they have built up, not because they do not know how to make the ware, but simply because they cannot compete with the low wages which prevail in Central Europe.

Par. No. 218 (e) Czechoslovakia. Glass Containers, Produced Otherwise than by Automatic Machine (except filled with perfume, etc.) On hand-made bottles of the container type only, already concessions have been made through the French Treaty which gave a fifty percent reduction to hand-made bottles imported filled. It should be recognized that a practice has grown up and exists in increasing proportions wherein foreign perfume manufacturers, particularly those of France, manufacture their perfumes in the country where they are packaged. The statistics would seem to indicate that it is not desirable to use the imported bottle in preference to the domestic bottle for that purpose.

Because of this practice a large industry has grown up to satisfy the demands of both the domestic perfumery manufacturers and the foreign concerns manufacturing in this country.

Par. No. 218 (e) Czechoslovakia. Glass Containers (except Holding Perfumery, Etc.) Fitted or Designed for Use with Ground-Glass Stoppers and Produced by Automatic Machine, Filled or Unfilled. Hand-finished automatic ma-

chine-made bottles with hand-made and ground-in stoppers customarily used in laboratories and commercially as acid containers are an important sales volume to several of our manufacturers. During the war, there was an unusually heavy demand for this type of ware and large volume was produced. During normal times there is a steady and reasonably large number used. We recall orders in the millions for bottles with ground glass stoppers for Army and Navy laboratories, as well as industrial research projects which were directly interested in the production of war material. Fortunately, this branch of the industry had enough volume prior to the war with sufficient personnel trained in the making of this delicate type and enough finishing apparatus so that when this enormous war demand developed, these trained people could act as leaders for untrained personnel, finally breaking them in so that the ware could be produced in the required volume.

Par. No. 218 (f) Czechoslovakia and United Kingdom. Table and Art Glassware. In the nine months of 1946, imports have equaled within $100,000 of the total imports for these classifications in 1939. If the same ratio is maintained for the last three months of the year, the total yearly imports will more than equal the total 1938 volume of $2,000,000 for these classifications. This will have occurred the first year after the close of the war when the heavy shipping Central and Eastern European glass-producing countries are emerging from a war fought mostly on their territory. Yet they are able to resume shipments in practically the same volume as when war began. They were supposed to have been so crippled that it would be most difficult to start production again and we could look forward to practically no shipments from them for a considerable period after the war closed.

If, under these great handicaps, they have been able to accomplish so much under the present tariffs which are claimed to be such a hindrance to them, we can anticipate a very much larger volume from them as they enter a more normal period and if U. S. tariffs are lowered, they will have a further competitive advantage by the aid of our own government.

Par. No. 218 (f) United Kingdom. Table and Art Glassware Valued at Not Less Than $1 per Piece. The tariff has already been reduced from 60% to 45% in the U. K. agreement. Their manufacturers are placed in a preferred position in this market and Sweden, France and Czechoslovakia all have benefited from the reductions which have been made.

Par. No. 218 (f) Czechoslovakia. Table and Art Glassware Valued at Less than $1 per Piece. In this classification is Mexican bubble glass which has already been reduced from 60% to 30% and which Czechoslovakia has never made. Not only is the advantage of helping Mexico lost when you urge another country to go into the production of their specialty, but you also injure American manufacturers by building up a line of ware at ridiculously low prices to further shatter and depress other comparable end use lines made in this country.

Par. No. 218 (g) Czechoslovakia. Pressed, Unpolished Glass Table and Kitchen Articles. In the settlement of world affairs, it is now the intention to allow Germany and Japan to produce only non-military manufactured articles and glass will be one of these items. Every effort, then, will be advanced by both of these countries to excel in that business. At present, the United States Commercial Company is planning to rehabilitate these industries and send the glassware produced by them to this country. With this in view, U. S. manufacturers of glass-making machinery are being urged by the government and private sources to produce and send the latest glass-making machines, with instructors on how to run them, to these countries. As they become proficient in machine production, which will not be in the too far distant future under the competent instructions that they will receive, a serious threat to this branch of the industry exists. This advantage is particularly emphasized because these countries will all operate on a very much lower wage scale than is paid for the same operations in the U. S.

Already numerous representatives from other countries have been in this Country and are reported to have placed orders for substantial quantities of automatic glass-making machinery which will be placed in production in foreign countries within the next year or two. Then these foreign factories will be competitive with U. S. producers and will be paying a much lower wage scale. These same representatives according to reports received from our members have sought admittance to U. S. plants in order to obtain the "know how" and experience of the U. S. producer.

With this increased automatic machine capacity, the foreign producers will naturally shrink the export markets of the U. S. producers and these foreign producers will surely seek the attractive domestic market in this country. When the U. S. manufacturers are compelled to share to any great degree the U. S. market, their production costs will then be spread over a smaller volume and consequently will increase. These higher costs will result in higher prices here and that will further place the U. S. producers at an added disadvantage when competing in their own markets against the low wage-paying competition both here and in the foreign export market.

Par. No. 230 (d) Czechoslovakia. Glass Manufacturers, N.S.P.F.: Other Glass and Glassware. Any cut in tariff in this classification will be discouraging to U. S. manufacturers who may start making a new item of an industrial nature only to find that the same item is taken abroad by some of their customers where, due to the lower labor rates, it is made cheaper. Thereby this country is deprived of the possibility of the development of certain new lines that might amount to considerable sales value if they had been allowed to be manufactured here under a tariff which would equalize low labor rates of foreign manufacture with high U. S. labor rates.

Orme Sees Threat to American Wage-Earner in Tariff Reduction

Addressing the Committee for Reciprocity Information on January 29, W. L. Orme forecast that tariff reduction would seriously injure the glassware industry; demonstrated that such injury would entail reduction of labor's purchasing power; and pleaded that action be tabled until formulas be determined for equalizing foreign wages with domestic. Mr. Orme is President of Cambridge Glass Co., Cambridge, Ohio.

Referring to himself as a business man rather than a trained economist, Mr. Orme forecast that any general lessening of the tariff on glassware would greatly reduce

(*Continued on page* 98)

IMPROVING GLASS FEEDER OPERATION THROUGH ELECTRONIC PNEUMATIC CONTROL

By J. R. GREEN and E. A. MURPHY
Brown Instrument Company, Division of Minneapolis-Honeywell Regulator Company

The manufacture of glass, dating back as it does to the year 2100 B.C., has always been a skilled trade. In earlier days, its secrets were jealously guarded and glass making processes as late as the year 1900 differed little from those employed 500 to 1,000 years before. The rare dexterity and careful judgment required were entirely dependent upon the individual worker, laboring under rather primitive conditions with a material little understood and haphazardly controlled. During the twentieth century, the glass industry has made tremendous strides forward, and its present highly efficient machines and high capacity continuous furnaces are due, to a great extent, to perfected methods of temperature control.

In feeder operation, where the glass is conditioned and its temperature stabilized, precise control is of vital importance, since a change of one degree F. in the molten glass can cause a variation of approximately one per cent in the weight of the finished bottle. Feeder temperature is also a critical factor in determining machine speeds, thus exerting a limiting influence on the maximum gross pack.

The problem of designing an adequate feeder control system was complicated by many limitations. Ambient conditions in many glass plants are, in general, highly unfavorable, and the recording and controlling instrument must be exceptionally rugged and constructed to operate with a minimum of maintenance. It must be a precision measuring instrument, capable of recognizing and correcting for fractions of a degree of temperature deviation. Continuous control is essential—control that responds instantly to the smallest temperature change. The instrument itself must be of practical construction, containing a minimum of moving parts and complicated adjustments. It must be liked, as well as easily understood by the machine operator.

After many months of tests under commercial operating conditions in the plant of a well-known glass manufacturer, a highly satisfactory control system was perfected. These tests were carefully followed by the Hartford-Empire Company.

Fig. 1

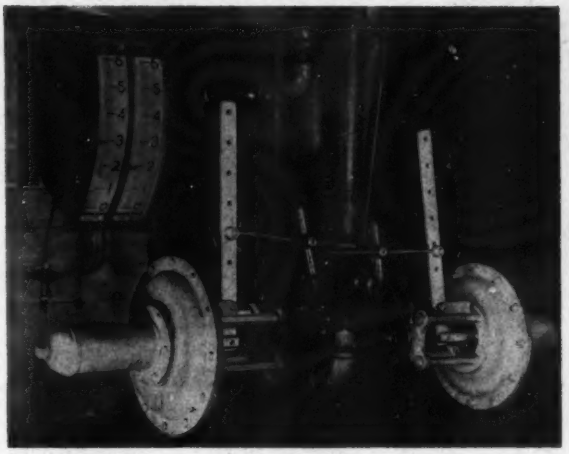


Fig. 2

Instrumentation. The primary measuring elements in all cases are platinum—platinum rhodium thermocouples immersed directly in the molten glass. Couples may be bare or protected by a platinum sheath, and are installed sufficiently far into the glass to obtain a truly representative temperature. For flint glasses, bare couples are almost universally used. With semi-opaque glasses such as amber, blue, green, and others, protected couples, extending well into the molten glass, are usually preferred. On a given feeder, couples of identical composition are used in the spout and channel. Installations involving a second or rear channel, of course, require the use of a third couple.

To accomplish the successful operation of the entire control system, the Brown ElectroniK Air-O-Line controller which overcomes all of the objectionable limitations previously mentioned was developed. Because it contains no galvanometer and because there is no motion of parts only when a change in the measured temperature takes place, this instrument is unaffected by vibration and requires a minimum of maintenance. The "Continuous Balance" principle employed by this instrument eliminates the time consuming cyclic balancing action inherent in the operation of mechanically balanced potentiometers, and provides instantaneous response to minute temperature changes. The large, easily read dial and convenient external index setting knob and standardizing button provide the operator with a continuous indication of feeder temperature and enable him to make any necessary adjustments without opening the instrument case.

Two controlling instruments are used, one controlling the spout temperature, while the other performs a simi-

(*Continued on page* 104)

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Furnaces

Patent No. 2,413,037 is an electric melting furnace assigned to Corning Glass Works by Charles F. DeVoe. This furnace is said to be capable of the continuous production of glass of optical quality.

Fig. 1 is a horizontal section of a tank according to this patent. The tank comprises a long narrow melting end 11 which forms the head of a T. A conditioning section 12 forms the vertical part of the T. Batch is introduced through openings in the roof near the ends of the melting section 11. The batch is melted by submerged rods 26, 26¹, 27 and 27¹ positioned near the feed openings.

The tank 12 is divided into two conditioning sections 13 and 14 by a bridge wall 20 having a submerged throat. The glass is delivered through a platinum tube which projects above the bottom of the tank as shown by dotted lines at the left of the figure. An opening is also provided above the glass level so that it may be gathered by hand. The glass in the conditioning sections is kept at the desired temperature by heating elements 35 above the metal line and supplied with current from a suitable source indicated by X and Y. Other connections are provided to regulate the temperature of the rods 26, 27 and 26¹ and 27¹.

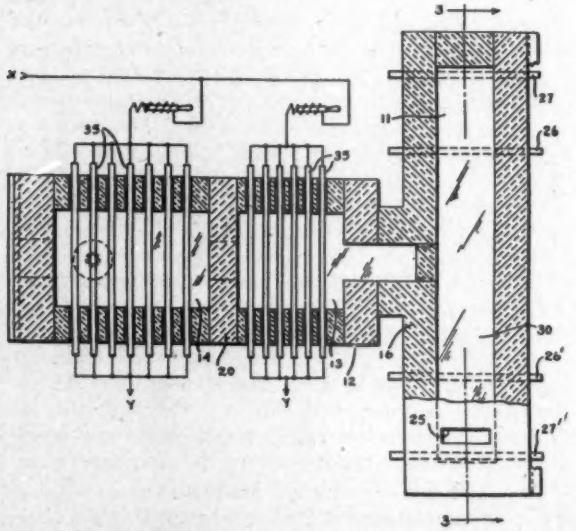


Fig. 1. Corning Electric Melting Furnace

Glass Compositions

Patent No. 2,414,413 is on a selenium-containing glass and it was assigned to Battelle Memorial Institute by Arnold E. Pavlish and Chester R. Austin.

When selenium glass is being made by the usual methods, there is a big loss of selenium during melting thus making it necessary to add much more selenium to the batch than is desired in the finished glass. This loss is especially large in making selenium ruby glass.

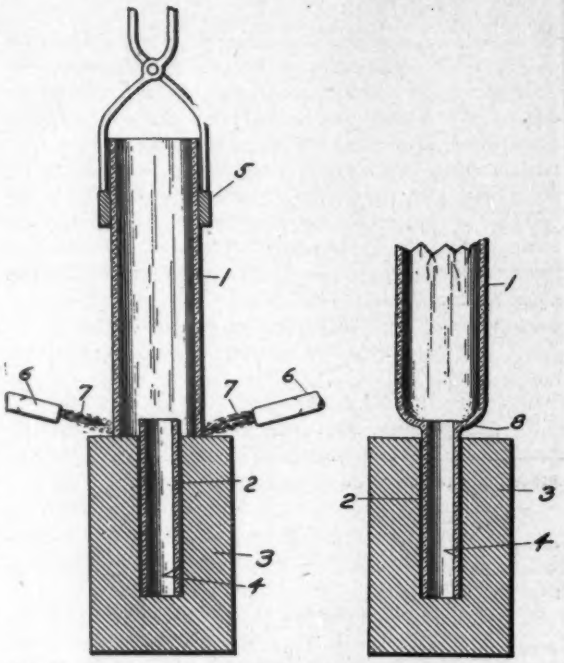


Fig. 2. Method of Sealing Electronic Tubes

These inventors have found that this loss may be greatly reduced by adding a small amount of silicon, silicides or alloys containing silicon to the selenium in the batch.

The following table shows the effect of silicon additions on selenium recovery in a series of tests. The tests were made by pouring 500-gram batches into crucibles at 2700°F. holding the melt at that temperature for about two hours and then making the glass article.

Test No.	Colorant[1] Per Cent Se	Colorant[1] Per Cent CdS	Silicon Addition Kind	Silicon Addition Per Cent	Silicon Content Per Cent	Selenium in Glass Per Cent	Selenium Recovery Per Cent
83..	1.0	..	.....	..	..	0.01	1.0
84..	1.0	..	Si	0.25	0.25	.66	61.0
1..	1.0	0.6	.....	..	..	.013	1.2
2..	1.0	.6	FeSi ..	1.0	.90	.77	71.0
3..	1.0	.6	SiC ..	1.0	.70 [2]	.53	48.9
4..	1.0	.6	CaSi ..	1.0	.601	.46	42.4
25..	.35	.35	FeSi ..	.125	.112	.04	10.5
31..	.35	.35	TiSi ..	.34	.136	.09	23.7
81..	.35	.35	FeSi ..	.18	.162	.07	18.4
28..	.35	.35	CaAlSi	.42	.202	.15	39.5
82..	.35	.35	FeSi ..	.25	.225	.18	47.4
30..	.35	.35	ZrSi ..	.53	.295	.26	68.5
35..	.20	.20	FeSi ..	.30	.27	.16	14.7
38..	.20	.20	CaSi ..	.73	.44	.20	92.1

[1]Based on weight of glass batch.
[2]Theoretical silicon content.

Patent No. 2,413,549 discloses a glass or vitreous composition having a very low electrical loss which makes it useful for dielectric purposes. This composition was invented by Alden J. Deyrup and assigned to E. I. du Pont de Nemours & Co. The patent resulted from an

earlier application, Serial No. 504,888 filed in 1943.

Materials of this character have been used in the manufacture of electrical capacitors or condensers as shown in a patent application filed by Ballard on which no patent has yet issued. The materials previously employed have been subject to dielectric losses which were highly objectionable in radio apparatus and similar devices. The electrical losses are measured in terms known as the "Q-value" and the greater the Q-value, the better the material for these purposes. Fused quartz has been used for work of this kind, but it is difficult to make an account of its high melting point.

The patent provides a glass having a workable melting point which has all the advantages of fused quartz.

The following table gives twelve examples of batch compositions in weight per cent, by which this new glass may be made. The patent should be examined for more detailed information.

Ingredients	Batch											
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*
Red lead (Pb_3O_4)	48.5	50.9	49.6	49.2	50.4	41.7	49.2	50.0	39.1	37.4	36.9	47.3
Flint (SiO_2)	24.2	25.4	22.3	24.6	25.2	20.7	24.6	25.0	19.6	18.8	18.4	23.6
Potassium carbonate ($2K_2CO_3.3H_2O$)	4.0	12.7	4.1	...	4.2	3.5	4.1	12.5	3.3	3.1	3.1	3.9
Soda ash (Na_2CO_3)	2.4	...	2.5	...	...	2.1	2.5	...	2.0	1.9	1.8	2.4
Lithium carbonate (Li_2CO_3)	1.6	...	1.7	4.9	1.7	1.3	1.6	...	1.3	1.2	1.2	1.6
Sodium fluoride (NaF)	4.0	4.2	4.1	...	4.2	3.5	4.1	4.2	3.3	3.1	3.1	3.9
Potassium fluoride (KF)	...	...	...	5.7	...	...	...	...	...	...	...	...
Magnesium oxide (MgO)	3.2	6.8	3.3	3.3	3.4	2.8	1.6	6.6	...	...	...	...
Strontium nitrate ($Sr(NO_3)_2$)	12.1	...	12.4	12.3	2.5	24.4	12.3	...	22.9	32.5	...	11.8
Zinc oxide (ZnO)	...	...	...	...	8.4	...	...	...	...	...	9.2	...
Barium carbonate ($BaCO_3$)	...	...	...	...	...	...	...	...	...	...	24.5	...
Whiting ($CaCO_3$)	...	...	...	...	...	...	...	...	6.5	...	...	...
Beryllium oxide (BeO)	...	...	...	...	...	...	...	...	...	...	...	5.5
Antimony oxide (Sb_2O_3)	...	...	...	...	...	...	...	1.7	...	...	...	...
Sodium zirconium silicate (55% ZrO_2, 29% SiO_2, 14% Na_2O)	...	...	...	...	...	...	...	...	2.0	2.0	1.8	...

Miscellaneous Processes

Patent No. 2,413,159 discloses a new glass bonded ceramic material. It is an invention of Woldemar A. Weyl of State College, Pa., who assigned it to Monsanto Chemical Company.

It is usual to make ceramic bodies having good electrical and mechanical properties from clay and flint with feldspar as a bond. This invention proposes the use of apatite or monazite with a multicomponent trivalent metaphosphate glass as a bonding agent.

The inventor has an application still pending in the Patent Office claiming a ceramic body in which the glassy matrix is composed of a multicomponent phosphate glass. This patent discloses a better material than that of the pending application.

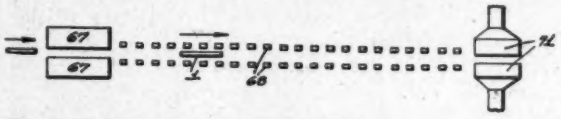


Fig. 3. Method of Tempering Glass Sheets

One claim of the patent is as follows: A ceramic body comprising from 70 per cent to 95 per cent by weight of refractory phosphate particles bonded together by means of from 30 per cent to 5 per cent by weight of a multicomponent phosphate glass essentially comprising a trivalent and a divalent metal metaphosphate.

Patent No. 2,413,338 is an invention by Wallace H. Small of Waltham, Mass. on a method of sealing exhaust tubulations to electronic discharge tube envelopes. It was assigned to Raytheon Manufacturing Company of Newton, Mass.

The process of sealing these parts has heretofore been carried out by hand and even with highly skilled operators, the seal was often weak and subject to breakage. This invention proposes a method which can be carried out by automatic machinery using less highly skilled labor and, at the same time, producing a stronger tube.

In Fig. 2, a tube 1 which may have an outside diameter of about one-third of an inch, surrounds the projecting end of an exhaust tubulation 2 having an outside diameter of about one-eighth of an inch. These measurements are given because the invention is particularly adapted for working on small size tubes. The tube 2 is supported in a block 3 while the larger tube is held by a clamp 5 so that it just touches or slightly clears the block 3. Burners 6 direct flames 7 against the lower edge of the tube 1. The burners or the tube supporting mechanism are arranged to rotate so as to heat the entire lower marginal portion of the tube 1. When the edge of the tube has been heated to the softening point, the surface tension of the soft glass and the pressure of the flames cause the tube to draw inwardly into contact with the tube 2 forming a seal 8 as shown at the right of the figure. The projecting top of the smaller tube 2 is sufficiently heated by radiation so that a good seal can be made.

Patent No. 2,413,722 is on a method of tempering glass sheets and it was issued to Bernard Long of Paris,

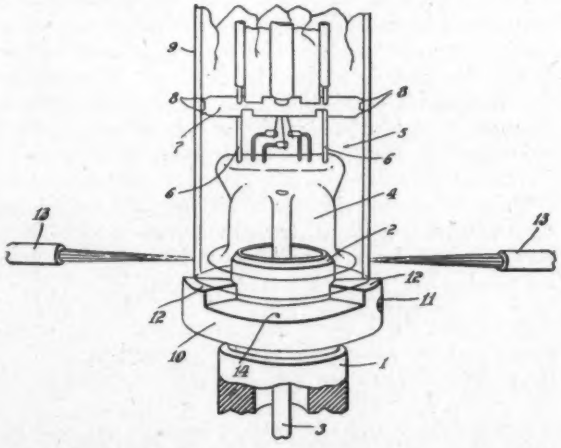


Fig. 4. Machine for Sealing Radio Tubes

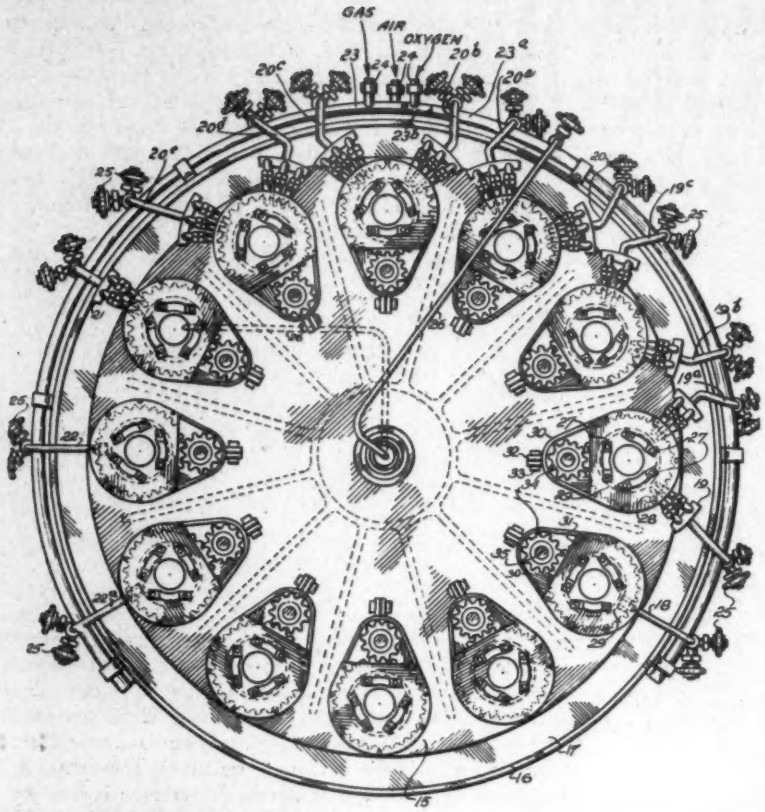


Fig. 5. Eisler Bulb Sealing Machine

France. The title is now vested in the Alien Property Custodian and rights under the patent may be obtained under the usual terms.

Tempered sheet glass, as now being made, is subject to irridescent spots when viewed in certain lights and these detract from the appearance and value of the glass. These spots are produced by the irregular cooling which is usually done by a series of nozzles. Attempts to overcome this defect have not been wholly successful.

The original application for this patent was filed April 2, 1936 and Patent No. 2,303,749 has already issued. The earlier patent shows different methods and apparatus for overcoming the same objectionable spots.

Fig. 3 is a diagram showing how the method of this patent may be carried out. A sheet 1 passes through a heating oven 67 and then between two rows of hollow cooling bars 68. These bars have slits extending across the sheet and blow cooling air across the whole sheet. In order to save air, a series of valves are provided which open to cool the sheet only when the sheet is in front of the associated cooling bars.

The cooling may be completed by the bars 68 or, after passing the critical temperature, the final cooling may be done by any well-known blowing device as indicated at 71.

Patent No. 2,413,766 is on a machine for sealing together parts of radio tubes. It was invented by Otto G. Honzl and assigned to Union Radio Corporation of Newark, N. J.

In accordance with the present practice, the relative position of the two parts to be sealed is dependent entirely upon the skill and judgment of the operator. Naturally, this is subject to variation with the result that the parts may be damaged, a poor seal may be formed and the finished tubes may vary in overall length. This invention provides a device which overcomes all of these objections.

In Fig. 4, there is shown a center pin 1 having an opening which supports and positions the exhaust stem 3 depending from the flare 4 of the mount unit 5. Adjustably secured to the pin 1 is a sealing collar 10 having shoulders 12 to support the bulb 9. The openings between the shoulders permit the flame from burners 13 to heat the bottom edge of the bulb 9 and also the bottom of the flare 4.

The mechanism shown is mounted on a standard sealing-in machine by which the parts to make the seal are uniformly heated while rotating. When the bottom of the bulb 9 contracts so that it contacts the flare, the parts are at substantially the same temperature and a good seal is made while the parts are held in definite relation.

Patent No. 2,413,960 is on a bulb sealing machine and the inventor is Charles Eisler of South Orange, N. J. The machine automatically seals the stems carrying the filaments into the necks of the lamp bulbs. The machine is of the turret type with 12 heads which advance step by step to the work stations.

In Fig. 5, there is shown a circular plate 15 carried by a base 16 formed with a trough 17 which receives the waste ends of the bulbs. Each head has cleats 27 which support the bulb carried by a gear 28 in mesh with a pinion 34. Through connections below the plate 15, these heads are caused to rotate when in position at certain work stations.

The parts to be sealed are placed in position at the bottom of the figure and then pass in a counter-clockwise direction to a pre-heater 18 to two stations having cross-burners 19, 19a, 19b and 19c. The head then moves to other burners 20, 20a, 20b, 20c, 20d and 20e and to a burner 21 where a lower heat is applied. At this station, the neck of the bulb will drop into the trough 17 and, thereafter, the finished bulb will be annealed by burners 22 and 22a. The bulbs are then removed and the heads reloaded. Gas, air and oxygen are supplied to feed pipes as indicated and the various burners may be regulated by valves 25.

The construction of the heads may be somewhat as shown in Patent No. 1,655,050 issued to Mr. Eisler on January 3, 1928.

• Consumers Glass Company of Montreal, Canada, has purchased an 18-acre site at Chatham, Ontario, for immediate erection of a new plant to manufacture glass containers for food products and for the proprietary trade.

Research Digest

The Rate of Creep at Elevated Temperatures of Four Sillimanite Tank Blocks

Previous work by others indicated that the measurement of the rate of elongation under load at high temperatures (a measure of the viscosity of the glassy matrix) of samples of tank blocks would indicate their likely behavior under industrial conditions in a glass melting tank. Boow and Walker (*Journal of the Society of Glass Technology*, February 1946) have, therefore, measured the rate of creep at elevated temperatures on samples of four sillimanite tank blocks and have compared the results with other data such as texture, porosity and corrosion resistance in an attempt to evaluate the different samples in respect to actual performance.

The texture of the blocks was assessed by visual examination, partly by photographs of the broken and ground surfaces at a magnification X5. The apparent porosity of each block was determined by the method adopted as standard by the Society of Glass Technology in 1938 (*Journal of the Society of Glass Technology*, Proceedings, 1938, 22, 102), a number of such determinations being made because of the variation in the porosity value from point to point throughout the block, and the mean value recorded.

To determine the rate of elongation of specimens at high temperatures, a special apparatus was constructed (the original paper should be consulted for details). Specimens, approximately 18 cm. long and 1 cm. square cut by a carborundum wheel from the tank blocks, were suspended from a supporting stand which was part of the low-temperature viscosity apparatus adapted for that purpose. The elongation under load was measured by an optical lever system which produced a magnification of 200 times. The elongation of the specimen in the furnace was measured every half hour up to a maximum period of 100 hours if failure did not take place. During this period, the temperature was maintained within $\pm$ 10° of the test temperature.

The corrosion resistance of the blocks was determined by two methods. In the first method, a 1-inch cube was cut from each block and suspended for a period of 24 hours in a glass of composition 73 per cent SiO_2, 10 per cent CaO, 17 per cent Na_2O, at a temperature of approximately 1400° C. Each specimen was then cut in half and the ratio of the area penetrated by the glass to the total cross-sectional area of the specimen was expressed as a percentage.

The second method consisted in suspending rods of 1 cm. square cross-section in 100 gm. of a soda-silica glass of composition 70 per cent SiO_2, 30 per cent Na_2O in a platinum crucible. Owing to the difficulty of maintaining constant conditions over a long period of time, a high temperature of 1500° C. was used to promote rapid attack. After five hours, the specimen was raised just above the glass, allowed to drain for 30 minutes and then removed. The glass was then maintained at 1450° C. for four hours to become more homogeneous and then analyzed for R_2O_3 content. The increase in R_2O_3 content of each glass and the appearance of the test specimens were used as a measure of the corrosion resistance of the blocks.

A comparison of the results of these tests showed that the creep test would indicate the worst block (as shown by the corrosion tests) but that it would not differentiate between blocks of intermediate properties. It was concluded that these experiments on the rate of elongation of the four specimens of slip cast sillimanite tank block serve to provide further evidence of the usefulness of this test as a means of assessing the durability of refractory materials. A more severe test of its merits will be forthcoming when the performance of the blocks under industrial conditions becomes known.

Lead-Nickel Glass of Controlled Chemical Durability for Storage Battery Use

The addition of very small amounts of soluble nickel salts to the electrolyte of a storage battery markedly decreases the end-of-charge voltage. However, this effect is fugitive, disappearing in a few cycles. The problem of decreasing the end-of-charge voltage is thus one of continually supplying nickel ions to the electrolyte to perpetually renew the catalytic layer of nickel. Williams and Orsing (*Journal of the American Ceramic Society*, November 1946) in attempting to solve this problem believed that the use of glass would be an ideal solution. This becomes apparent when the attack of solutions on glass is considered, particularly as to mechanism.

Considerable data on the chemical durability of glass is available. The pertinent data may be summed in a number of generalities as follows: 1) The rate of reaction is roughly a linear to parabolic function of time. 2) The rate of reaction is a linear function of the surface area. 3) The log of the rate of the reaction is a function of the reciprocal of the absolute temperature or, over short temperature ranges, it may be considered a linear function of the temperature. 4) The rate of reaction is a complex function of composition. (Generally, simple, two and three component, glasses have lowered durability.)

A lead silicate glass containing nickel was prepared on a laboratory scale and subjected to chemical durability tests. These solubility tests were sufficiently encouraging to suggest a trial of the glass in a storage battery. Consequently, a series of batteries was prepared, the negative plates of which contained nickel glass equivalent to a nickel content varying from 0.00006 to 0.047 per cent.

The results obtained showed that a nickel containing lead-silicate glass when incorporated into the battery plate paste makes the effect on voltage permanent by continuously supplying nickel ions to the electrolyte and, moreover, improves the cold capacity of the battery during its life.

As a result of this work, lead-nickel glass has been

(*Continued on page* 88)

PROPOSED STANDARD DEFINITIONS

Accompanying a letter addressed to the members of the Glass Division of the American Ceramic Society, O. G. Burch, Chairman of the Division, has presented for consideration by the membership the following proposed standard definitions as submitted by the Committee on Classification and Nomenclature.

Members have been asked to carefully consider the definitions and express their approval or disapproval of them. Ballots for the purpose have been supplied which are to be in the hands of Dr. Samuel R. Scholes, Secretary of the Glass Division, not later than February 15. It is stated that the results of this balloting will be disclosed at the next annual meeting of the Society scheduled for the week of April 21 in Atlantic City, N. J.

PROPOSED STANDARD DEFINITIONS

Submitted by the Committee on Classification & Nomenclature Glass Division A.C.S.

annealing point. The annealing point of glass is the temperature at which the internal stress is substantially relieved in fifteen minutes. It corresponds to the equilibrium temperature at which the glass has a viscosity of $10^{13.4}$ poises, as measured by the loaded fiber method, using the equation:

$$\eta = \frac{mgl}{3\pi r^2 \frac{dl}{dt}}$$

η = viscosity in poises
m = load in gms.
g = acceleration due to gravity = 980 cm./sec./sec.
l = heated or effective length of fiber in cm.
r = fiber radius in cm.
$\frac{dl}{dt}$ = elongation rate in cm./sec.

The annealing point corresponds generally to the upper end of the annealing range.

chemical durability. The chemical durability of glass is the lasting quality (both visible and chemical) of a glass surface. It is frequently evaluated, after prolonged weathering or storing, in terms of chemical and physical changes in the glass surface, or in terms of changes in the contents of a vessel.

cord. A cord in a glass article is an attenuated glassy inclusion possessing optical and other properties differing from the parent glass.

deformation point. The deformation point of glass is the temperature observed during the measurement of expansivity by the interferometer method at which viscous flow exactly counteracts thermal expansion. The deformation point generally corresponds to a viscosity in the range from 10^{11} to 10^{12} poises.

fining. The fining of glass is the process by which the molten glass approaches freedom from undissolved gases.

liquidus temperature. The liquidus temperature of glass is the temperature at which equilibrium exists between the molten glass and its primary crystalline phase.

melting. Melting of glass is the thermal process by which the batch charge is completely converted into molten glass free from undissolved batch.

melting temperature. The melting temperature of glass is the range of furnace temperature within which melting takes place at a commercially desirable rate, and at which the resulting glass generally has a viscosity of $10^{1.5}$ to $10^{2.5}$ poises. For purposes of comparing glasses, it is assumed that the glass at melting temperature has a viscosity of 10^2 poises.

setting rate. The setting rate of glass is a comparative term referring to the time required for the glass surface to cool between the limits of the working range. A short time implies a fast setting rate, and a long time implies a slow setting rate.

softening point. The softening point of glass is the temperature at which a uniform fiber, 0.5 to 1.0 mm. diameter and 22.9 cm. long, elongates under its own weight at a rate of 1 mm. per minute when the upper 10 cm. of its length is heated in a prescribed furnace (Jour. Amer. Cer. Soc., 10, 259 (1927), at the rate of approximately 5° C. per minute. For a glass of density near 2.5, this temperature corresponds to a viscosity of $10^{7.6}$ poises.

working range. The working range is the range of surface temperature in which glass is formed into ware in a specific process. The "upper end" refers to the temperature at which the glass is ready for working (generally corresponding to a viscosity of 10^3 to 10^4 poises), while the "lower end" refers to the temperature at which it is sufficiently viscous to hold its formed shape (generally corresponding to a viscosity greater than 10^6 poises). For comparative purposes, when no specific process is considered, the working range of glass is assumed to correspond to a viscosity range from 10^4 to $10^{7.6}$ poises.

A.S.T.M. STANDARDS ON GLASS AND GLASS PRODUCTS

Issued for the first time by the American Society for Testing Materials is a special compilation of 96 pages including various standardized definitions, tests methods and specifications for glass developed in A.S.T.M. work primarily through the activities of Committee C-14 on Glass and Glass Products.

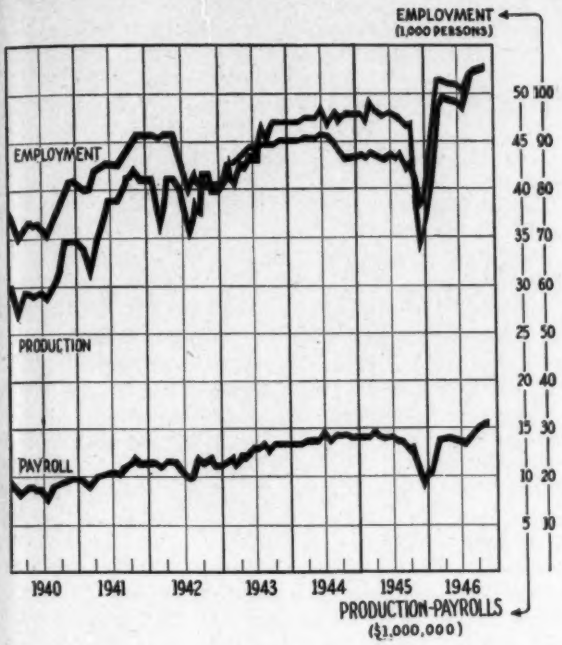
There are methods for the chemical analysis of glass sand, and soda-lime glass and a standard procedure for flexure testing of glass. Three methods cover glass containers: the hydrostatic pressure test, polariscopic examinantioam thdnaer
amination and thermal shock test. Two specifications cover pin-type lime-glass insulators and there are also methods for testing these products. Other tests cover glass spool insulators, glass yarn and woven glass fabrics. The evaluation of glass tubular sleeving and braids, and the testing of woven glass tapes is also covered.

Copies of the publication, paper cover, can be obtained from A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa., at $1.25 each.

• The first 1947 meeting of the Trenton Section of the American Ceramic Society was held January 24. This was the Section's annual meeting and election and installation of officers took place. Mr. J. A. Meister of the Mathews Conveyor Company was guest speaker and spoke on the broad field of materials handling.

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



November 1946 figures for the glass industry, as shown by the Production Index, indicate an approximate increase of 1½ per cent over the figure for October. The figures estimated are $56,000,000 for November and close to $55,500,000 for October. The figure reported for November 1945 was $34,750,000. Total output for the January-November 1946 period is about $548,500,000. During the corresponding period in 1945, an estimated total of $500,550,000 was reached.

Employment and payrolls: The total number of persons employed in the glass industry during November 1946 was 104,500 persons. This is slightly under the figure reported for October, which was an approximate 105,000 persons. During November 1945, the employment figure reported was 76,800.

Payrolls for November 1946 were about $15,700,000, an approximate 1½ per cent increase over the $15,500,000 reported for October. Payrolls for November 1945 were $9,500,000. Glass manufacturers have paid out approximately $144,500,000 in salaries during the first eleven months of 1946 as compared with $141,555,000 during the same period in 1945.

Glass container production for the month of December 1946, based on figures released by the Bureau of Census, indicated a decrease of about 2 per cent. Production for December was 9,341,215 gross and for November, 9,609,787 gross. The December figure, however, is about 8 per cent over the 8,604,979 gross reported for December 1945. Glass container production has reached a total of 115,746,570 gross for the year 1946. This figure establishes an all-time high for glass container manufacturing. It will be recalled that another all-time high was established for a single month when August 1946 production reached a total of 10,658,710 gross. At the close of 1945, production had reached a total of 105,368,925 gross, which is an approximate 9 per cent under 1946 production.

Shipments of glass containers for December rose slightly to a total of 9,663,285 gross for the month. November shipments were 9,573,862 gross. Shipments for December 1945 were 8,107,248 gross, or about 19 per cent below December 1946. Total shipments made during the year 1946 were 116,002,796 gross, while for

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in gross)

		Production December 1946	*Stocks December 1946*
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries & Cosmetics	Narrow Neck....	2,991,250	1,589,368
	Wide Mouth...	3,221,911	873,146
Dairy Products		344,313	156,851
Home Canning		*125,320	36,312
Beverages, Returnable		568,258	362,738
Beverages, Non-returnable		.....	.....
Beer, Returnable		636,512	60,171
Beer, Non-returnable		34,466	†.....
Liquors		956,916	129,668
Wines		388,316	60,262
Packers' Tumblers		73,953	17,907
Total		9,341,215	3,591,447

*This figure represents Fruit Jars only.
†This figure included with "Beer, Returnable."

GLASS CONTAINER SHIPMENTS

(All figures in gross)

	December 1946
Narrow Neck Containers	
Foods	723,478
Medicinal & Health Supplies	1,192,350
Chemical, Household, Industrials	575,663
Beverages, Returnable	512,956
Beverages, Non-returnable	.....
Beer, Returnable	598,127
Beer, Non-returnable	40,700
Liquors	949,235
Wines	392,852
Toiletries & Cosmetics	657,184
Sub-Total (Narrow)	5,642,545
Wide Mouth Containers	
Foods	2,803,232
Dairy Products	331,410
Home Canning	*43,930
Medicinal & Health Supplies	290,799
Chemical, Household, Industrials	72,039
Toiletries & Cosmetics	95,360
Packers' Tumblers	77,931
Sub-Total (Wide)	3,714,701
Total Domestic	9,357,246
Export Shipments	306,039
Total Shipments	9,663,285

*This figure represents Fruit Jars only.

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the same period in 1945, shipments were 106,653,861 gross—a difference of about 8 per cent.

Inventories of glass containers at the close of December 1946 were 3,591,447 gross. For November, they were 3,904,578 gross and for December 1945, 4,328,458 gross.

Plate glass production for December 1946 continued to drop, according to the Hughes Statistical Bureau. The month indicated a decrease of about 12 per cent—that is, 20,780,809 sq. ft. produced during November and 18,410,848 sq. ft. during December. During December 1945, 429,381 sq. ft. were produced. For the 12-month period of 1946, plate glass production totalled 210,006,188 sq. ft. as compared to 84,589,324 sq. ft. produced during the corresponding period in 1945.

Automatic tumbler production for the month of December 1946 decreased about 5½ per cent to 6,470,409 dozens. During November, 6,847,675 dozens were produced and during December 1945, the figure reported was 5,681,565 dozens. Shipments for December 1946 also fell off and were 6,241,588 dozens. This is about 4 per cent below the 6,526,513 dozens shipped during November. During December 1945, shipments were 5,925,147 dozens. Stocks on hand at the close of December 1946 were 4,879,003 dozens. At the close of November 1946 and December 1945, they were 5,543,761 and 5,281,196 dozens, respectively.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware for December 1946 dropped about 27 per cent from the 3,167,937 dozens reported for November to 2,298,384 dozens. The figure reported for December 1945 was 3,203,439 dozens. Total manufacturers' sales for the twelve months of 1946 were 46,942,453, as compared with 32,211,793 dozens sold during the corresponding period in 1945.

RESEARCH DIGEST . . .

(*Continued from page* 85)

in commercial use in batteries for approximately four years and has stood the test of varying conditions in a number of plants. Its use is well established and will undoubtedly continue.

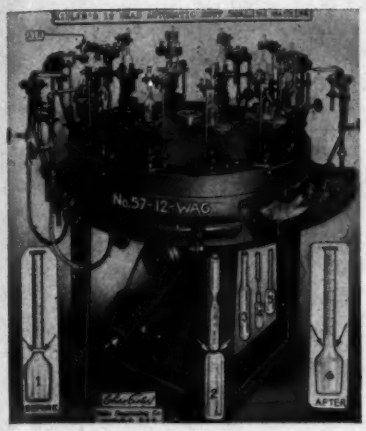
From the data obtained during this investigation, it is indicated that glass can be utilized for a continuous supply of ions to a leaching solution over extended periods of time. Data on the chemical durability of glass may also be used as a guide in formulating a glass for the intended use.

BROWN INSTRUMENT ADDS TO STAFF

The Brown Instrument Company has announced the appointment of 38 new sales and service engineers to 23 of its branches throughout the United States and Canada.

The 38 newly assigned sales and service engineers have just completed an intensive course in industrial instrumentation at the Brown Instrument School from which many industrial engineers have graduated during the past eleven years. The course comprised specialized instruction, in addition to the technical education which each engineer had had previously.

NEW EQUIPMENT AND SUPPLIES



EISLER BUTT-SEALING MACHINE

Eisler Engineering Company, Newark 3, New Jersey, has recently placed on the market a new 12-head automatic butt-sealing machine to improve and speed up production on special cylindrical glass work requiring butt-sealing.

The machine is powered by a ¼ HP electric 1750 R.P.M. motor with variable speed pulley. The intermittent motion of the indexed turret is performed by a Geneva mechanism, while the heads, kept continually rotating around their own axis, are driven by an endless chain and friction wheel combination mounted inside of the completely enclosed turret. A circular track is further provided inside the table, machined in such a way to allow lowering or raising the head-chucks as required by the technological sequence of the butt-sealing operation.

On this 12-head machine, there are seven fire positions, with burners adjustable in height, which accomplish the butt-sealing, and three fire positions which perform the annealing operation. The two heads in front of the operator are idle (not rotating) and only allocated for loading and unloading the work. On the last fire position, an air jet is provided to permit compressed air of 1½ lbs. per sq. in. to enter the work. The operation of the machine is fully automatic and all the operator has to do is to put the bottle and stem onto the idle loading position and to discharge the finished work from the unloading position.

The machine is available in different models and can be adapted for many various types and shapes of glass articles, especially in the pharmaceutical field. Its production is approximately from 400 to 650 per hour, depending mainly on the size of work.

LINK-BELT ELECTROFLUID DRIVE

The Link-Belt Company, 307 N. Michigan Avenue, Chicago 1, Illinois, has announced the development of a compact, motorized hydraulic combination to be known as Link-Belt Electrofluid Drive. It will be available in horsepowers up to 20 and consists of a general purpose A.C. induction motor flange mounted on a sturdy housing containing a hydraulic coupling.

Its output shaft may be direct-connected to the driven machine or to a speed reduced unit. It may also be connected to driven machine through the medium of chain, gear or belt drives.

RECORDER CHART LEGIBILITY IMPROVED

Bailey Motor Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, has introduced recorder charts printed in neutral gray. It is said that this makes it easier for operators and supervising engineers to read the charts because of the greater emphasis given the various colored records by the neutral background.

The new charts are especially valuable, it is stated, on recorders installed where lighting is poor or where it is impossible to get a clear view of the chart.

Bailey charts are made from wax engraved plates and the center holes are punched simultaneously with the printing to insure accurate centering.

BROWN DEVELOPS NEW CUT-OUT SWITCH

Brown Instrument Company, Division of Minneapolis-Honeywell Regulator Company, has developed a new cut-out switch for centrally located periodic temperature measurements. The switches are especially adaptable to the chemical and petroleum industries.

The cut-out switch consists of a double-pole, double-throw mechanically operated push-button switch for multi-point indicators.

CATALOGUES RECEIVED

A. P. Green Fire Brick Company, 1801 Railway Exchange Building, St. Louis 1, Missouri, has issued a booklet to tell about the formation of the A. P. Green Engineering & Management Company and to describe the services offered to selected individuals or organizations interested in buildings and operating firebrick or allied clay products plants outside continental U. S. A.

The booklet, entitled "For Tomorrow's Firebrick and Allied Clay Product Plants . . .", explains the purpose and functions of the newly formed division of the A. P. Green Fire Brick Company. The company offers engineering and management service to refractory and allied clay plants throughout the world. It will give reports and procedures to guide and improve the construction of new plants, the operation of existing plants, the selection, purchase and exporting of equipment and overall operation and management.

American Society for Testing Materials, 260 South Broad Street, Philadelphia 2, Pa., has announced two publications in the field of adhesives.

One is a Symposium issued by the Society during 1946 and contains seven technical papers. It is available at $1.00 per copy.

The other is a paper by Dr. Weyl of Pennsylvania State College dealing with the Theoretical Basis of Adhesion. This paper was presented at the Society's 1946 annual meeting and is now available in reprint form for 50c.

Rapids-Standard Co., Inc., Dept. BC-72, 308 Peoples National Bank Building, Grand Rapids 2, Michigan, has issued a two-color, thirty-two page catalogue containing descriptions, photographs and specifications of the company's entire line of power belt conveyors.

This is the first time all Rapids-Standard power belt conveyors have been grouped together in one catalogue. Illustrated are the portable Challenger and Defender models of the Rapid Power Booster; the portable Stevedore, Jr., for use in loading, unloading and stacking materials; the permanent installation-type Floor-Veyor, used principally in conveying materials between floors; various applications of these models as horizontal belt conveyors; and the Press-Veyor, used in conveying stampings and small parts in punch-press rooms.

The catalogue shows, in an isometric cutaway illustration, how various Rapid Power Boosters play important roles in an integrated material handling system. Actual installation photographs are shown and detailed drawings and close-up photographs show points of Rapids-Standard construction and complete specification tables.

Buffalo Forge Company, P.O. Box 985, Buffalo 5, New York, is distributing a bulletin, No. 3576, describing the new Buffalo Industrial Exhauster.

The new 32-page bulletin illustrates and describes the exhausters, and rating tables for all models are included.

Jessop Steel Company, Washington, Pa., has issued a new 24-page catalogue illustrating and describing tools, dies and wear resisting parts made from "Malta" cemented carbide and "T" and "V" cast non-ferrous alloy.

Specifications are given for standard "Malta" carbide tool tips, tools and wire drawing dies and for "T and V" cast alloy tool bits.

IDENTIFICATION OF STONES IN GLASS . . .

(*Continued from page* 74)

In addition to the above set, a large supply of 1.51-index liquid should be available for general work, such as in preliminary studies of thin sections or of pieces of glass suspected of bearing crystals.

(b) Relief: When a solid is immersed in a liquid or in another transparent solid the clarity or sharpness with which the solid remains visible is termed *relief*. If the liquid and solid (or the two solids) differ greatly in indices of refraction, the immersed solid stands out boldly and is said to have *high relief*. Conversely, if the two materials are similar as to refractive index, the immersed solid is scarcely visible and is said to have *low relief*. With experience, the operator can learn to estimate from the relief the approximate difference between the indices and thus have a guide in his choice of the next immersion liquid to be used.

(c) Index comparisons in immersion liquids: A small amount of the crushed material to be tested is mounted on a microscope slide in an immersion liquid and examined under the microscope. As in all petrographic work, the crystals to be studied are first located under low magnification and then are studied at progressively greater magnifications. Whenever crystal indices are being determined, great care must be taken that crystal-liquid interfaces are being tested and not glass-liquid ones; only those portions of the crystal boundaries that are entirely free from glass can be used in these tests.

The comparative technique described below, the central-illumination method, is applied to determine whether the indices of the solid are less than or greater than that of the liquid, and an estimate of the magnitude of this index difference is made by means of the relief and the comparative test. Then, based on these first results, a second liquid of appropriate index is chosen; a new mount is prepared, and a second check is made. The choice of the second liquid is governed by the desire to bracket the index of the solid by those of the two liquids. As soon as this bracketing is accomplished, the next liquid is chosen to lie about half way between the two bracketing liquids. This process is repeated until the solid's indices are located. Obviously, if at any time the tests indicate that the solid indices lie near to that of one of the liquids, this will control the choice of the next liquid. If at the end of the testing the solid indices are found to lie between those of two adjacent liquids, these two liquids can be mixed so as to yield an intermediate index, if such precision is warranted. To do this, a drop of one of the liquids is placed on a microscope slide, and an equal-sized drop of the second is placed near the first but not touching it. These two drops are then thoroughly mixed by means of a steel probe. A little of the powdered solid is sprinkled on the liquid mixture; a cover glass is added, and the mount is ready for examination under the microscope.

(d) Central-illumination method: A little of the crushed material, mounted on a microscope slide in an immersion liquid is placed under the microscope. Observations are made with parallel (not crossed) nicols, no auxiliary condenser, no accessories, and magnifications of 100× to 450×. The intensity of the illumination is reduced by means of an iris diaphragm until the Becke line effect becomes prominent at the particular interface under test (this may be the glass-crystal, liquid-crystal or glass-liquid one) when the barrel is raised or lowered from the focus position. This effect consists of two bands of light concentration, the Becke lines, at, for example, the solid-liquid boundary; these bands move in opposite directions across this interface whenever the barrel is moved from the focus position. When the barrel is raised from below the focus position to above the focus position, the more prominent Becke line moves toward the medium of higher index—this is the basis of the test. As successive liquids that are nearer to the solid in index are used, the intensities of the two lines become more nearly equal, and the outlines of the solid tend to disappear.

When the indices of the two mediums are very near to each other, color effects* occur at their interface. The color in the edge of the solid and that in the boundary of the liquid become interchanged as the barrel is raised from below focus to above focus. The key colors, to be used as a guide in the final comparisons, can be summarized as follows:

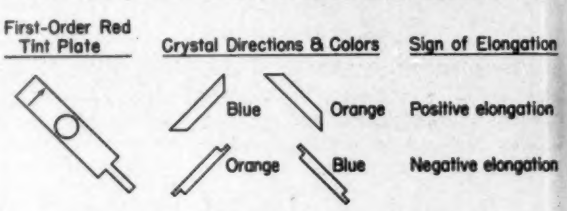


Fig. 1. Color effects in the test for sign of elongation when the crystal fragment shows only black and white under crossed nicols without the tint plate.

Color Effects at Solid-Liquid Boundary	*Index Relationship*
Blue and yellow	Liquid near solid but low
Green and burnt orange	Liquid same as solid
Blue and brown	Liquid near solid but high

(3) Sign of Elongation. When crystals are found that exhibit an elongated appearance, needlelike (acicular) or lathe-like (bladed), their *sign of elongation* can be determined easily. The crystal in question is rotated on the microscope stage until its direction of elongation is parallel to the arrow that is marked on the first-order red tint plate. If, under crossed nicols with the tint plate inserted, the crystal shows *blue* (equivalent to crystal retardation *plus* the tint-plate retardation) in this orientation, it has *positive elongation*. However, if it shows *orange* (crystal retardation *minus* the tint-plate retardation) in this position, it has *negative elongation*. When the crystal is rotated 90°, so that it is perpendicular to the arrow, the color effects are the reverse of those given above, that is, a positive-elongation crystal will show orange (crystal retardation minus the tint-plate retardation). These relationships are indicated in Fig. 1.

The blue and orange colors hold for crystals showing no colors other than blacks, greys and whites under crossed nicols without the tint plate. Sometimes, fragments are found that show, particularly in their thicker parts, yellows, oranges or reds under these conditions,

(*Continued on page* 92)

*The index of the liquid and those of the solid vary with the wavelength of light (dispersion), but the liquid index varies much more than those of the solid. When the indices are very near to each other, the solid index is the lower of the two for short wavelengths but is the higher for long wavelengths. This difference causes the color effects.

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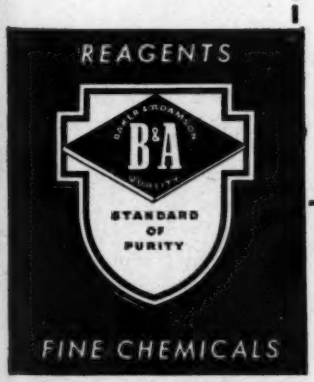

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(*Continued from page* 90)

thus indicating relatively thick crystals of fairly high birefringence. In such cases, the sign-of-elongation test will yield in these parts greys or yellows instead of oranges or blues. However, some parts of the crystals usually will be thin enough to show the blue-orange tests discussed above. The colors to be expected in any case can be determined from a retardation color chart such as is given in reference (1); the color will be either that corresponding to the crystal color, without the tint plate, plus the 565 mμ retardation due to the tint-plate, or that corresponding to the crystal color minus the 565 mμ, depending upon the sign of elongation and the orientation of the fragment.

(4) Extinction. When one of the crystals that are found in glass stones is rotated on the microscope stage under crossed nicols, it will become alternately bright and dark four times during a complete revolution. (As in the case of birefringence, this effect is not present in isotropic minerals or in various other mineral fragments having certain special orientations.) *Extinction* is this property exhibited by most of the crystals of becoming black at 90° intervals of rotation. Some crystal aggregates extinguish by stages, rather than all together; nevertheless, crystals will usually be found showing complete extinction at some given position of rotation of the stage. If a crystal in the position of extinction is parallel, either as to elongation or as to pronounced cleavages, to the vibration planes of the polarizing elements the crystal has *parallel extinction*. (These vibration planes are parallel to the crosshairs in the east-west and north-south positions when the polarizer 0° mark is at the reference line on its mounting.) Should a crystal show extinction at some other angle to these principal directions, it has *oblique* or *inclined extinction*. (Certain crystals exhibit rhombic cross-sections with the extinction being parallel to their diagnosis; this is called *symmetrical extinction*.) Only monoclinic or triclinic crystals show inclined extinction, and these, particularly monoclinic ones, may show parallel extinction also. If a particular mineral can have inclined extinction of a certain maximum amount (angle from the crosshairs) then fragments of this mineral may exhibit extinction at any angles up to this maximum value. Hence, in order that this maximum angle may be found, tests must be made on a number of these crystal fragments; the maximum angle found in these measurements is used as the extinction angle. In the work at hand, it is usually sufficient to determine simply whether the extinction is parallel or inclined.

IV. Types and Properties of Glass Stones

The general types of glass stones will be briefly outlined in this section, and the properties of the various kinds of crystals (minerals) found in the stones will be presented in considerable detail. A natural classification of glass stones is that based on the source of the stones, since all tests on stones are directed toward determining that source. The detailed relationships of the individual minerals in a stone to the source of that stone are discussed in part (D) below.

(A) *Batch Stones*

Stones caused by incomplete solution of batch materials can be readily identified, and the conditions causing them can be corrected comparatively easily in most cases. Proper control of particle size and moisture content normally eliminates this type of stone. Coarse sand is particularly dangerous; the lime, feldspar, etc., must also be watched carefully in this respect.

Cullet is another offender; bad stones and foreign material should be excluded from the cullet. Pieces of refractory adhering to quarried cullet are particularly troublesome.

(B) *Refractory Stones*

Probably the most prolific sources of stones are the refractories of the furnace or pot. All types of refractories can cause trouble to a greater or lesser extent depending upon the particular conditions. Pieces of the refractory itself as well as products of glass or vapor attack upon it are found in glass stones.

(C) *Devitrification Stones*

Devitrification can be caused in glass melting by inadequate temperature, off-composition glass or combinations of these. The relationship of glass composition in a particular part of a furnace to the crystal types to be expected there upon devitrification cannot be determined exactly. Obviously, if chemical analyses prove the absence of certain oxides in the glass associated with stones, crystals containing these oxides will not be present in the stones. However, in certain cases, surprisingly small amounts of a particular oxide have permitted crystallization of compounds of that oxide.

(D) *Properties of Glass-Stone Minerals*

In order to provide a tabulation of pertinent crystal properties in a form that is useful at the microscope, Table I has been prepared. The writer has attempted to list the distinctive properties, if they are available in the literature, for most of the minerals found in glass stones. Of necessity, the remarks are much abbreviated, but in each case the essentials have been retained. The more common minerals, (1) through (15), are listed above the horizontal division line and the rarer ones below it, each group being arranged in order of increasing index of refraction. Various other rare minerals have been reported in the literature, and the list in the lower half of Table I is, therefore, somewhat arbitrary.

V. Equipment

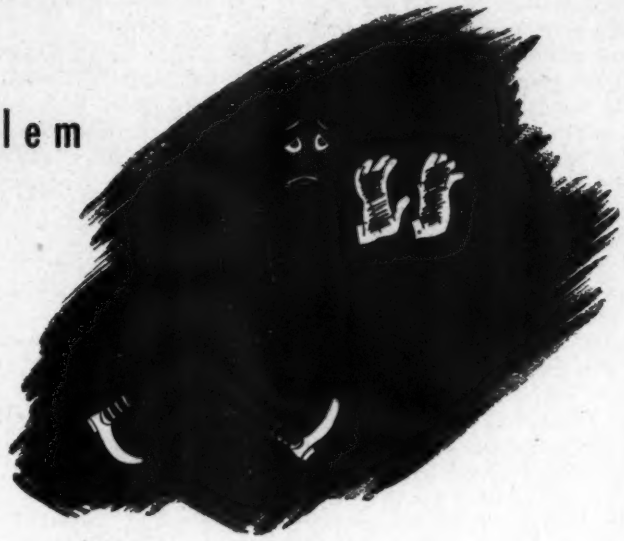
(A) *Petrographic Microscope*

The petrographic microscope is a polarizing microscope; that is, it is constructed so as to utilize either ordinary or polarized light. From the mirror the light proceeds upwards through the polarizer. This polarized light then passes through the sample on the microscope stage, thence into the analyzer, and on to the eyepiece. The analyzer should be readily removable from the light path so that the sample can be examined as if in ordinary light. It is convenient to have the analyzer rotatable, but this is not a necessity. Either the stage or the oculars must be equipped with centering screws. Typical objectives to be used with a 10× ocular have magnifications of about 3×, 10× and 45×; normal

(*Continued on page* 94)

2 WAYS

to approach a color problem



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(*Continued from page* 92)

work requires the use of all three objectives, the lowest power objective being used first in each instance. (Interference-figure tests are made under the 450× magnification; the low-magnification combination, 30×, is used in ring-section examination of glass ware.)

The most needed accessory is the first-order red (gypsum or synthetic) tint plate*; the quartz wedge and the quarter-wave plate are used but rarely. Each of these is designed so as to be readily insertable into the microscope barrel below the analyzer. A mechanical stage greatly facilitates the systematic examination of microscope slides and is recommended as a very useful accessory. (If considerable petrographic work including the determination of interference figures is to be done, a Bertrand Lens is convenient; also, an auxiliary condenser lens between the regular condenser and the stage is necessary for any interference-figure tests.) A useful instrument having the above features is the LA Petrographic Microscope, No. 31-28-54, offered by the Bausch and Lomb Optical Company.** Similarly, the No. 42 AC Petrographic Microscope manufactured by the American Optical Company† is designed for this type of work.

A special microscope illuminator is necessary to provide adequate illumination. These are available from both the American Optical Co. and the Bausch and Lomb Optical Company.

(B) *Immersion Liquids*

A set of calibrated immersion liquids for this work should cover refractive indices from about 1.41 to 1.78 in steps of 0.01 and should come in ¼-oz. bottles with applicator rods. Such sets are obtainable from R. P. Cargille, 118 Liberty Street, New York 6, New York.

In addition to such a set, 1 ounce of a liquid with index 1.51 is needed, also in an applicator bottle.

(C) *Microsection-Preparation Apparatus*

(1) Lap Wheels. The grinding of thin sections is done on two flat, horizontal wheels about 12″ in diameter made of soft cast iron, one lap being used exclusively for coarse grinding and the other for fine. Each wheel should have a friction drive and a speed of about 600 r.p.m. It should be mounted in a watertight pan that shields the wheel mounting and catches the abrasive discharge from the wheel; a drain pipe with a stopcock is useful on each pan. The tops of the pans should be about one to two inches above the wheel and should be mounted flush in a heavy table of about elbow height. There should be a hinged lid over each wheel so that the fine wheel can be shielded from all coarse abrasive. Usually, this equipment is constructed by the user.

(2) Hot Plate for Balsam Mounts. The plate should maintain a temperature of about 100-150° C and should be covered with one or two layers of thin asbestos paper. Either electric or gas-burner plates can be used; resistors may be needed in series with electric plates in order to maintain the correct temperatures.

(3) Glass Plate for Final Grinding of Thin Sections (Approx. ⅜″ x 9″ x 12″).

(4) Abrasives for Grinding of Thin Sections. Coarse grinding—120 carborundum (The Carborundum Co., Niagara Falls, N. Y.); Fine grinding—240 or FF carborundum; Glass-plate grinding—600-mesh alumina (Buehler Ltd., 165 W. Wacker Drive, Chicago 1, Illinois).

(5) Miscellaneous. (a) Microscope slides—26 mm. x 46 mm. (Williams, Brown and Earle, Inc., 916 Chestnut St., Philadelphia 7, Pa.), or 25 mm. x 75 mm. (Any laboratory supply house); (b) Boxes for storing prepared slides; (c) Cover glasses—¾″ x ¾″, ½″ x ½″, or ½″ circles. (Any laboratory supply house); (d) Canada balsam—paper-filtered balsam or solid balsam. (Any laboratory supply house, or Bausch & Lomb Optical Co.); (e) 100-mesh sieve—about 3-in. diameter. (Newark Wire Cloth Co., 351 Verona Ave., Newark 4, N. J.); (f) Agate mortar and pestle—about 55 mm. diameter. (Any laboratory supply house), or two steel blocks about 1-in. square with polished faces; (g) Water supply—600-ml. erlenmeyer flask with one-holed stopper fitted with glass-tube nozzle, or water jar fitted with syphon delivery tube; (h) Small corks, steel plate (approx. ¼″ x 6″ x 8″) for cooling mounts, forceps, chamois skin or lens tissue, diamond pencil, black glazed paper for handling powdered material, small sample vials, pure acetone in 1-oz. dropper bottle, acetone or xylene for cleaning slides, glass cutters, wire cutter for cutting and trimming samples, microscope-slide labels, two Pyrex-brand glass rods approx. ⅛″ diameter and 6″ long, burner. (Any laboratory supply house.)

VI. Selected References

(A) *Optical Theory, Microscopic Techniques:*

(1) A. F. Rogers and P. F. Kerr, OPTICAL MINERALOGY, 2nd ed., McGraw-Hill Book Co., Inc., New York, 1942, Part I (First edition is entitled THIN-SECTION MINERALOGY, 1933).

Chapter II The Polarizing Microscope

Pp. 9-29 **General Discussion** through "2. Crossing the Nicols".
See especially the section on **Parts of the Microscope.**

Chapter IV Refraction

Pp. 46-47 **Indices of Refraction of Anisotropic Minerals**

Pp. 55-59 **The Determination of the Index of Refraction with the Microscope**

Pp. 59-60 **Relief**

Chapter V Plane Polarized Light in Minerals

Pp. 61-65 **Polarized Light** to **Nicol Prism**

Pp. 78-82 **Direction of the Vibration of Slow or Fast Rays** to **Anomalous Interference**

Chapter VII Color, Form or Aggregation, Cleavage, and Orientation

Pp. 113-130 **Color and Pleochroism** to **Orientation**

(*Continued on page* 96)

*This tint plate should have a retardation of 565 mμ.

**Bausch and Lomb Optical Co., 642-3 St. Paul Street, Rochester 2, New York.

†Scientific Instrument Division, American Optical Co., Buffalo 11, New York.

3 REASONS

why you'll get better results

with **Kryolith**

REG U.S. PAT. OFF.

natural cryolite flux and opacifier

More and more leading manufacturers of glassware, ceramics and enameled goods are discovering that Kryolith has several distinct advantages over ordinary fluxes and opacifiers.

Translate these three plus factors in terms of your own problems:

1. GREATER UNIFORMITY AND PURITY — Kryolith is always uniform, a natural mineral. Pennsalt processing methods—backed by over 80 years' experience with cryolite—"float" out impurities to our established high standard of quality. This helps you improve the quality and uniformity of your finished products.

2. GREATER STABILITY — Kryolith itself undergoes practically no decomposition at fusion point (1000°C.), minimizes weight loss in batch during melting, protects refractory materials.

3. AVAILABILITY — With reserve stock piles of cryolite ore, adequate refining capacity and strategically located warehouse stocks of finished Kryolith, Pennsalt can assure you a steady supply of this superior flux and opacifier, thus helping to simplify formulation and production.

• Next time you formulate, be sure to use Kryolith . . . notice how it points up production, improves finished products. Why not try it now?

PENN SALT CHEMICALS

PENNSYLVANIA SALT MANUFACTURING COMPANY

1000 WIDENER BUILDING, PHILADELPHIA 7, PA.

NEW YORK • CHICAGO • ST. LOUIS • PITTSBURGH • CINCINNATI • WYANDOTTE • TACOMA • PORTLAND, ORE.

IDENTIFICATION OF STONES IN GLASS . . .
(*Continued from page* 94)

See also pp. 152-154

Chapter VIII Observation of Mineral Fragments
Pp. 135-138 **Crushed Fragments** to **Index Determinations by Immersion**
Pp. 140-142 **Form of Mineral Fragments**

(2) Ernest E. Wahlstrom, OPTICAL MINERALOGY, 1st ed., John Wiley and Sons, New York, 1943.

Chapter II Physical Properties
Pp. 15-17 Complete

Chapter III Elementary Optics
Pp. 18-19 **The Nature of Light** through paragraph on *Anisotropic Substances*

Chapter IV The Polarizing Microscope
Pp. 24-29 Complete

Chapter VI Measurement of Index of Refraction
Pp. 37-41 **Introduction** to **Oblique Illumination**

Chapter VIII Polarization of Light
Pp. 70-73 Complete

Chapter IX Uniaxial Crystals in Plane-Polarized Light
Pp. 74 as far as "Figure 1 shows . . ."
Pp. 86 **Extinction Angles** only

Chapter XI Optical Accessories
Pp. 104-105 **The Gypsum Plate** only

Chapter XII Sign Determination in Uniaxial Crystals
Pp. 116-117 **Sign of Elongation** only

(B) *Properties and Interpretation of Stones in Glass*

(3) H. Insley, "The Microscopic Identification of Stones in Glass", Jour. Amer. Ceram. Soc., *7* (1) 14-18 (1924). (His 'Sodium-Calcium Silicate' later was termed 'Devitrite'.)

(4) C. J. Peddle, DEFECTS IN GLASS, Glass Publications, Ltd., London, 1927.

(5) H. Insley, "Determination of the Source and Means of Prevention of Stones in Glass", Jour. Amer. Ceram. Soc., *12* (3) 143-152 (1929).

(6) E. S. Larsen and H. Berman, "Microscopic Determination of the Nonopaque Minerals", Geological Survey Bulletin No. 848, 1934. (Out of print.)

(7) Marcel Belliere, "Crystallization of Pseudowollastonite by Devitrification of Glasses", Glass Industry, *15* (9) 178-181 (1934).

(8) H. Jebsen-Marwedel, GLASTECHNISCHE FABRIKATIONSFEHLER, Julius Springer, Berlin, 1936, Pp. 99-171.

(9) A. Dietzel and L. Springer, "Simple Guide to the Characterization of Stones in Glass". Fachausschussbericht No. 37, Deut. Glastech. Gesellschaft 201-202 (1936). Abstracted very completely in Jour. Soc. Glass Tech., *21* (A) 166 (1937).

(10) A. J. Holland and Eric Preston, "Microscopical Examination and Identification of Crystalline Products in Commercial Glasses", Jour. Soc. Glass Tech., I, *21* 395-408 (1937); II, *22* 82-98 (1938). (173 photomicrographs.)

(11) Anon., "Properties of Glass Stones", Glass Industry, *19* (7) 272- (1938).

(12) See Reference (1): Part II *Descriptions of Individual Minerals and Mineraloids.*

(13) W. L. Fabianic, "Glasshouse Stones", Jour. Amer. Ceram. Soc., *27* (11) 330-350 (1944). (12 photographs, 65 photomicrographs.)

(14) V. D. Frechette and W. G. Hauth, "Petrographic Identification of Glass Stones", Jour. Can. Ceram. Soc., *15* 77-86 (1946); Ceram. Abstr. *1946* (11) 192, November.

The abstract of this paper appeared after the present manuscript was ready for publication. The original of the article is not available to the writer at this time.

(C) *Miscellaneous Special References*

(15) C. B. Slawson and A. B. Peck, "The Determination of Refractive Indices of Minerals by the Immersion Method", Amer. Mineralogist, *21* 523-528 (1936). (For advanced study only.)

(16) T. N. McVay, "Bibliography of Ceramic Microscopy", Bull. Amer. Ceram. Soc., *16* (2) 33-64, (1937).

(17) H. W. Fairbairn, "Gelatin-Coated Slides for Refractive-Index Mounts", Amer. Mineralogist, *28* 396-397 (1943).

(18) G. J. Zarbo, H. J. Hunt and D. C. Smith, "Analysis of Cords and Stones", Jour. Amer. Ceram. Soc., *27* (5) 138-142 (1944).

(19) G. C. Kennedy, "The Preparation of Polished Thin Sections", Jour. Economic Geol., *40* 353-360 (1945).

Acknowledgement

Several experienced petrographers kindly reviewed the present paper and contributed many valuable suggestions. For this material aid, grateful acknowledgment is made to W. F. Fabianic of The Owens-Illinois Glass Co., William Horak of The Hartford-Empire Co., Herbert Insley of The National Bureau of Standards, W. R. Lester of The Maryland Glass Co., K. C. Lyon of The Armstrong Cork Co. and Samuel Zerfoss of The Pennsylvania State College. The writer also wishes to acknowledge the sponsorship and kind cooperation of the Committee on Testing Procedures of The Glass Container Manufacturers Institute.

ACS ANNOUNCES ANNUAL MEETING

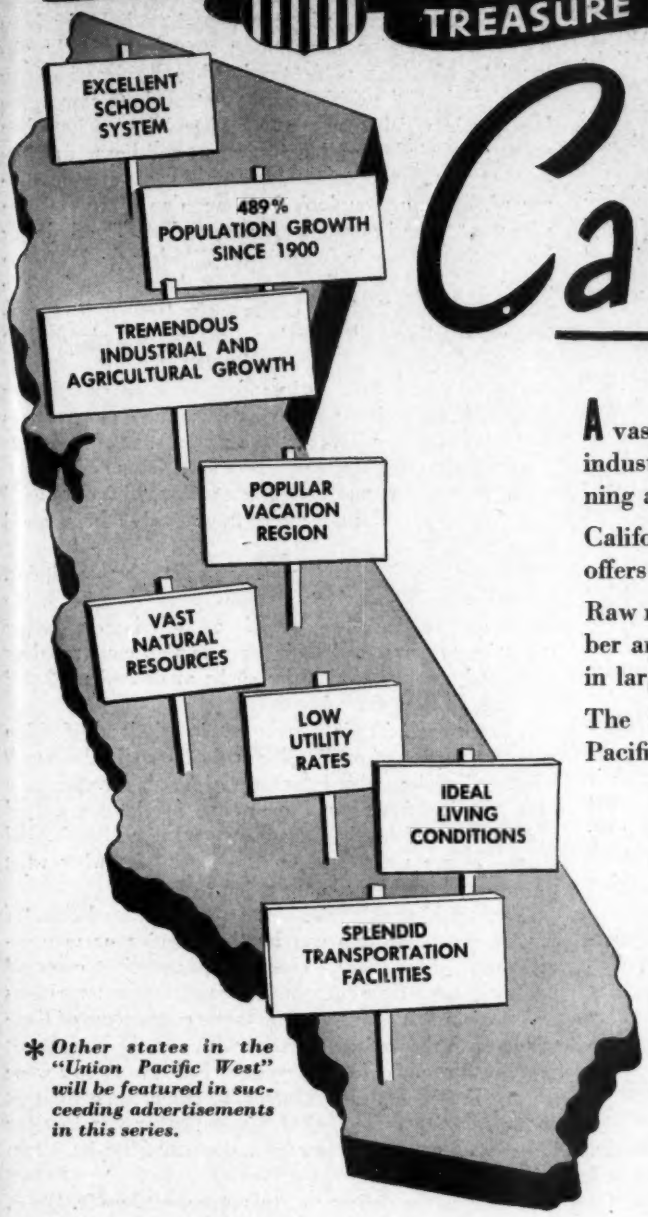
The American Ceramic Society has announced that its 49th Annual Meeting will be held in Atlantic City, New Jersey, April 21 to 25, 1947.

The Institute of Ceramic Engineers will meet Monday afternoon, while the reception for Division and Local Section officers and Committee Chairmen will be held Monday evening. The General Session will be Tuesday morning and the Division meetings will open Tuesday afternoon. Division meetings will close late Thursday.

UNION PACIFIC

TREASURE MAP OF INDUSTRY

California*



* *Other states in the "Union Pacific West" will be featured in succeeding advertisements in this series.*

A vast opportunity for development awaits industrial and commercial concerns planning a west coast location.

California's population, steadily increasing, offers a tremendous easy-to-reach market.

Raw materials . . . minerals, petroleum, lumber and agricultural products are available in large quantities.

The Golden State is ideally located for Pacific export trade.

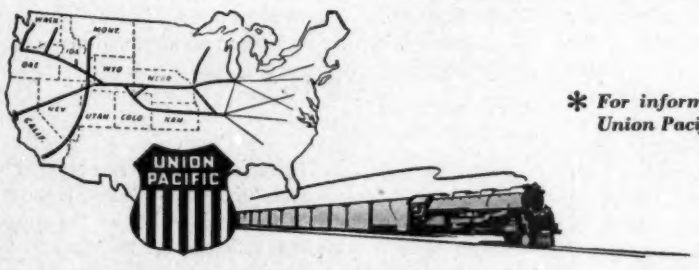
Hydro-electric power, nearby natural gas and oil fields, a mild all-year climate are industrial advantages.

Freight transportation facilities are unsurpassed. California is one of eleven western states served by the Union Pacific Railroad.

For industrial expansion, consider California. For dependable, all-weather transportation, to or from the West, we suggest—

be Specific – say "Union Pacific"

* *For information address Industrial Department, Union Pacific Railroad, Omaha 2, Nebraska.*



UNION PACIFIC RAILROAD

THE STRATEGIC MIDDLE ROUTE

RECIPROCAL TRADE AGREEMENTS . . .
(*Continued from page* 80)

the volume of hand-made glass produced in this country and that ultimately many articles now made by machine would be adversely affected. "Foreign producers," he said, "due to lower wages paid their workers, can sell their ware in this country, duty paid, at prices which we cannot meet, and in many instances at prices that will be less than our labor costs."

Labor in foreign glass-producing countries, said Mr. Orme, receives scarcely one-third of the rate per hour paid the average glass worker in this country. And in hand-production labor cost runs from 55 to 75 percent, averaging 63 percent, while in machine production it runs from 25 to 30 percent.

To supplement his statement, Mr. Orme filed with the Committee a "Brief of Craft Industry," by Dr. Frederick R. Macauley, economist. Dr. Macauley maintained that the craft industries (including hand-made glass) need tariff protection if they are to remain in a state of healthy activity. He stated that the problem is in essence purely a wage problem and that the American employer cannot afford to pay American wages and sell in competition with the distressingly low wages in so many foreign countries. He added "It is virtually a breach of faith for the United States Government to throw such an industry to the dogs — or, indeed, in any way to injure it — merely to help some of our over-developed mechanized industries to throw their products on foreign markets."

Although not indiscriminately opposing tariff reduction on imported machine-made ware, Mr. Orme warned that foreign manufacturers are already replacing their antiquated glass-producing machinery with our latest mechanical equipment, and that as soon as they have assimilated our know-how they will be able to compete with us in quality and with the distinct advantage of paying lower wages.

But even foreign hand-made ware can undercut American machine-made ware, he pointed out. "If the prices at which hand-made glass imports are sold in this country are low, this hand-made ware becomes highly competitive with U. S. machine-made ware. Since the former is made by hand it has popular appeal and, whether it is better or not, sells easier and seems like a bigger bargain to the ultimate consumer."

Not only is tariff reduction unfair to American labor, maintained Mr. Orme, but it is also unfair to labor and capital in countries like Britain, Sweden and some of the South American countries where a desperate attempt is being made to raise the wages and where wages have now reached a point where they are approaching half of the United States rate, but three times more than in Japan and China . . . "Take, for instance, Britain — where the skilled wages per day are perhaps $4.00 in the glassware business. The ware produced there has a labor content for one day of $4.00. The same ware produced in Japan for a day has a value of $1.00 labor content. Our duty on imported glassware is figured on an ad valorem basis, country of origin, and at the present glassware tariff rate of 60%, the Jap labor then is sold in this country for $1.60, while the British labor is sold for $6.40. Retail prices are customarily computed in this country on a flat percentage basis and the usual mark-up on cost is 100%. This labor then is sold to the United States consumer in the case of Japan for $3.20, while the British labor is sold for $12.80 on exactly the same kind of ware."

Just what happens when an American industry loses out against foreign competition was dramatically pictured by Mr. Orme: "As the hand-made glass industry would decline, the skilled workers struggle to stay in the business in which they are trained and love. First, they mortgage their homes, life insurance, and borrow money to start a cooperative factory. With this we are in entire accord. We in no way look down upon any group of men who want to be in business for themselves. The difficulty lies in their struggle for existence. Although these men are skilled in the art of making fine glassware — they are not educated in all phases of the business, such as marketing, cost finding and financing. As a result their product is priced lower than their actual cost and eventually they are forced to go out of business. Such was the case during the Czechoslovakian agreement when five cooperatives came into existence. Two of these are now out of business; the savings of the workmen have been lost; and, had it not been for the war and the lush market which developed in consumer goods as a result of it, probably others would have failed."

In recommending that tariff action be postponed, Mr. Orme declared that there is no need of decreasing the tariffs on glassware because all foreign glass-producing countries can now sell their ware in this country, duty paid, at lower prices than it can be made and marketed by United States manufacturers.

"This overall Trade Agreement in wholesale fashion with eighteen nations is ill-timed. It would be much wiser to develop with International Trade Organization first, get its charter and operating regulations agreed upon, approved by the Senate of the United States, and signed before we reduce our tariffs not knowing what the rules of world trade are going to be."

As a working formula, Mr. Orme submitted that "if foreign manufacturers can by their genius or management methods produce a cheaper glass product of equal quality — we believe that the system of free enterprise as practiced in this country requires the easy access of these products to the United States market. To the extent that this advantage of a foreign concern is due to its low wage scales, United States tariffs should compensate for that and then neither the United States worker nor investor is exposed to destructive exploitation that has its origin in low labor rates."

Following the delivery of this statement by Mr. Orme, Charles W. Carlson, President of United States Glass Co., also addressed the Committee on a subject of interest to only those association members making hand-made table and ornamental, stemware and tumblers.

Baruch Backs
A.G.A. Policy

In a letter to H. L. Dillingham, Business Manager of the American Glassware Association, Bernard M. Baruch expressed his approval of the basic policy of the American Glassware Association with respect to relations between tariff and labor standards and volunteered to use his influence to further it.

Recently the *Albany Times Union* quoted Mr. Baruch

(*Continued on page* 100)

Typical Death Valley California Scenery

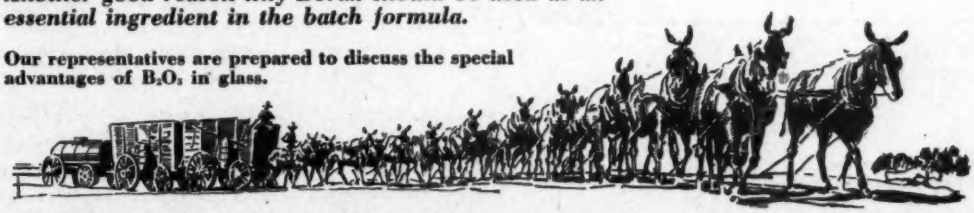
The characteristic desert prospector leads a lonely life with only his burro or burros for companionship. He has roamed over the mountains and through Death Valley for so many years that he has virtually become part of the scenery. Prospecting to him, is like a drug to a drug addict. If he isn't looking for gold, he's looking for a grubstake and he manages to chip out enough gold bearing ore to maintain the vision of eventually striking a bonanza.

It was just such a typical prospector whose first discovery of Borax in the early days of Death Valley, was responsible for the development of the organization which has long since produced the famous 20 Mule Team Borax products.

STRENGTH—Glass articles of certain types are frequently subjected to conditions in handling, transporting, packing, processing and general usage which demand definite strength characteristics. This property can be improved by making B_2O_3 one of the minor constituents of the glass.

Another good reason why Borax should be used as an essential ingredient in the batch formula.

Our representatives are prepared to discuss the special advantages of B_2O_3 in glass.



PACIFIC COAST BORAX COMPANY

51 MADISON AVENUE, NEW YORK 10, N. Y.

GLASS TANK FURNACES

again available

The constant demand for this useful and informative book has necessitated another printing.

Glass Tank Furnaces is the only book in the English language dealing comprehensively with glass tanks. Its contents include and describe in simple language, the most modern practices in design, construction, operation, behavior and economy of glass tanks. It is a book for the factory man, the technologist and for all who are interested in the practical aspects of glass making.

Glass Tank Furnaces contains 105 figures and illustrations—75,000 words typed in two columns and produced by the lithoprint process. Cloth bound, price $4.00. Foreign $4.50, F.O.B.

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Please enter my order for.....copies of Glass Tank Furnaces at $4.00 per copy.

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.....

RECIPROCAL TRADE AGREEMENTS . . .

(*Continued from page* 98)

as follows: "A vastly more discriminating formula is that mentioned by Bernard M. Baruch who proposed that we offer to impose no import duties on products from those nations which maintain wage and living standards equal to our own. Such a procedure would place some of the onus of tariffs where it belongs, namely on backward sweatshop nations which oppress their own nationals with meager wages and depressed social conditions."

Whereupon Mr. Dillingham wrote to Mr. Baruch: "If trade agreements could be made on the basis you have suggested, and as elaborated in our plan or one similar to it, much progress would be made toward raising the standard of living in countries with which we make trade agreements. Their wage rates could be eventually raised to our level instead of having United States wage levels broken down to foreign lower wage levels, which now seems to be the tendency."

Mr. Baruch replied: "I am certain that unless something is done along the lines I have suggested, about increasing the wage standards in other countries, we will sink back into economic difficulties that will bring other troubles which will result in war despite whatever is done. I shall use all my influence in the negotiations now taking place to bring about these higher wage scales in the rest of the world, lifting up their standards and not lowering ours."

ACS NOMINATES OFFICERS

The Board of Trustees of The American Ceramic Society has nominated the following men to the offices indicated: President, John D. Sullivan of Battelle Memorial Institute; Vice President, John W. Whittemore of Virginia Polytechnic Institute; W. E. Cramer of the Industrial Ceramic Products, Inc., has been renominated Treasurer of the Society; and Charles S. Pearce continues as General Secretary. These nominations will be voted on by letter ballot along with the nominations of Division officers.

At the meeting of the Board, reports were given on the California and Pacific-Northwest Local Sections and the Board moved that Dr. Barta be commended for his work in organizing the Czechoslovak Ceramic Society. Funds were also provided for the Ceramic Camera Club to offer as prizes for the three best industrial pictures pertaining to the manufacture of ceramic material. The prizes are to be $25, $15 and $10 and will be awarded at the Annual Meeting in Atlantic City.

L-O-F PERSONNEL DIRECTOR RECEIVES AIR FORCE AWARD

C. A. Carson, Personnel Director of Libbey-Owens-Ford Glass Company, has been awarded the Legion of Merit by the Army Air Forces. He served as Assistant Chief of Staff, A-1, to Lt. Gen. Barton K. Yount, commanding general of the Army Air Forces Training Command.

Citation for his Legion of Merit award was based on Mr. Carson's efforts in originating personnel policies and for outstanding administrative work. Mr. Carson joined Libbey-Owens-Ford in 1929 as Safety Director for all plants.

'nretouched photo — ports are blocked with canvas to exclude drafts during examination.

EXCELLENT OPERATION PLUS GOOD REFRACTORIES . . .

OPERATING DATA	
Melting Area, Not Including Doghouse (Sq. Ft.)	518.5
Tank Depth, Metal Line (Inches)	34
Total Days Life	1150.0
Total Operating Days	1089.8
Total Idle Days	60.2
Tons Glass Delivered	114,103.1
Tons Glass Per Operating Day	104.7
Sq. Ft. Melting Area Per Ton Glass Per Day	4.95
Tons Per Square Foot Per Life	220.0

THE furnace shown above has just finished a campaign of 1089.8 operating days, producing 220.0 tons of amber bottle glass per square foot of melting area during the campaign! (Rate of pull — 4.95 sq. ft. per ton per day.)

Superior glass-production records are primarily the result of superior operational techniques. This example is no exception. But it goes without saying that the operators are pleased with the performance of the Corhart Standard Electrocast with which the furnace was built — and we of Corhart* are pleased that these operators have been consistent users of Corhart Electrocast Refractories for many years.

Corhart Refractories Company, *Incorporated*
16th and Lee Streets, Louisville 10, Kentucky
In Europe: L'Electro Refractaire, Paris.

*Not a product, but a trade mark.

QUALITY · ECONOMY · ENDURANCE

CORHART ELECTROCAST REFRACTORIES

FAIRMOUNT GLASS REPRESENTED IN STATION DISPLAY

Fairmount Glass Works, Inc., is one of seventy-four Indianapolis manufacturers represented in a permanent industrial exposition which was recently opened in the Indianapolis Union Railway Station. This is a project of the Chamber of Commerce of Indianapolis.

Display cases of polished aluminum and plate glass are built to simulate observation coaches of streamlined trains. The exposition covers about 1,000 square feet in the train concourse of the station.

The Fairmount display, built by Cooperative Displays of Cincinnati, features glass-packaged foods, cosmetics and drugs, showing a variety of shapes. It is educational with a diagram of glass-making processes and display of several molds. The industry's slogan, "See What You Buy, Buy in Glass," is displayed.

In addition to its display of products, Fairmount Glass Works has also taken a section on the photomural display which is part of the exposition. A greatly enlarged photo shows the front of the glass works and several shop scenes in montage effect.

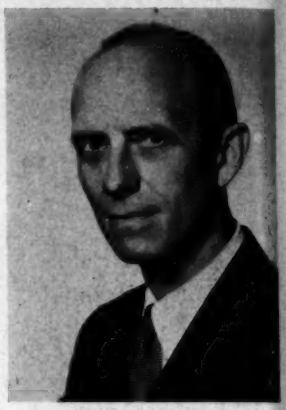
DIAMOND ALKALI EXPANSION PLANS

Diamond Alkali Company has announced another project in its 1947 plans for expansion and rehabilitation of plants and facilities. It is intended to build an administrative office and a research and development laboratory near Cleveland, Ohio, at an estimated cost of $2,000,000.

The project will be built on a tract of land approximating 80 acres located at Mayfield Heights and it is expected that transfer of the company's headquarters operations will come about during the first quarter of 1948.

SIXTON WOLLMAR NAMED H-E VICE PRESIDENT

The election of Sixton F. Wollmar as Vice President of the Hartford-Empire Company has been announced by F. Goodwin Smith. Mr. Wollmar has been Executive Vice President and a Director of SKF Industries, Inc.



Associated with SKF for more than 25 years, Mr. Wollmar was educated at Columbia University and abroad and is a graduate engineer who served as President of SKF Steel Company prior to becoming Executive Vice President of SKF Industries, Inc., in 1942.

During the war years, Mr. Wollmar guided the output of millions of anti-friction bearings for high priority industrial machinery and armaments, including the renowned Norden bombsight.

N. Y. METROPOLITAN SECTION TO HOLD FEBRUARY MEETING

The New York Metropolitan Section of the American Ceramic Society will hold its next meeting on February 19.

The Program Committee has arranged for a talk by W. J. Navin on "The Function of Patents in the Ceramic Field." Mr. Navin is a patent attorney with the Western Electric Company and has been associated with the practice and teaching of patent law for the last 18 years since receiving his law degree from the New York University.

PEMCO ISSUES NEW PRICE LIST

The Pemco Corporation has announced the release of a new price list which became effective January 1, 1947.

The new Price List is a continuation of the policy followed by Pemco prior to the war to issue a price list quarterly for the convenience of buyers of porcelain enamel frit, colors and mill additions. It also includes material and equipment used generally in plant operation.

The purpose of the Price List is to give essential information on the more important items furnished by Pemco so that orders may be placed without delay of obtaining quotations. The list also includes several pages of technical data and ample space for memorandums.

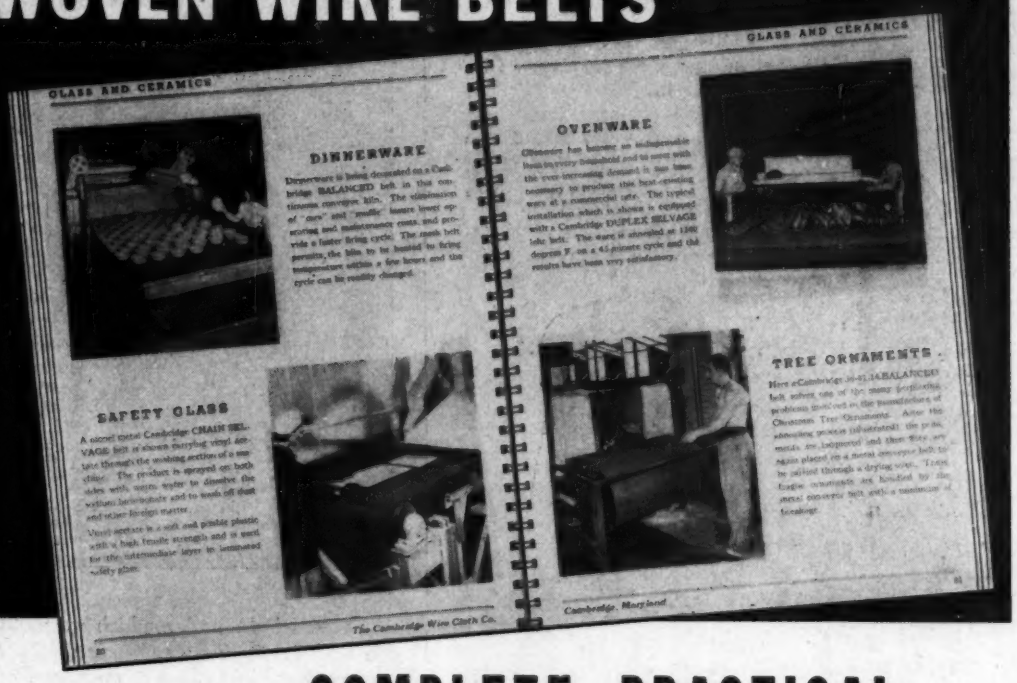
GLASS CONTAINERS, INC. MAKES APPOINTMENTS

Announcement has been made by Glass Containers, Inc., of the appointment of Francis W. McDonald as Vice President and General Manager, W. E. Boschin as Assistant General Manager, Vernon Rust as Resident Manager at Los Angeles and A. C. Larsen as Resident Manager at Antioch, California.

Glass Containers, Inc., is a wholly-owned subsidiary of Fibreboard Products, Inc., and D. H. Patterson, Jr., is President of both corporations.

FREE TECHNICAL BOOK

WOVEN WIRE BELTS



COMPLETE, PRACTICAL REFERENCE FOR ALL BELT USERS

HERE'S a valuable reference for any executive or plant man interested in efficient, economical conveying and treatment of industrial products. It contains complete information on Cambridge Woven Wire Belts — complete with technical details on conveyor applications, specifications, design and operation. For your free copy of this practical, illustrated handbook—and to learn how you can process and handle materials and products more efficiently, more economically with Cambridge Conveyor Belts — write today to Dept. 15.

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DUST·SEALED
for your
PROTECTION

You breathe pure, dust-free air in a batch room equipped with Smith Glass Batch Mixers. That's because the Smith is *dust-sealed during the entire cycle of operations* — charging, mixing and discharging. There's no chance for dust to escape. Practically eliminates the dreaded silicosis hazard. Promotes employee health and efficiency, at the same time producing quality glass batches in the shortest possible mixing period.

New 40 cu. ft. Smith Glass Batch Mixer equipped with dust boot which confines dust within mixer drum.

Smith Glass Batch Mixer in discharge position. Fast "Tilt and Pour" discharge.

SCIENTIFIC MIXING OF GLASS BATCHES

The Smith duo-cone drum is famous for its effective "end-to-center" mixing action. Vertical cascading and unnecessary agitation are avoided by substituting a less violent rolling action. Segregation is eliminated, for mixing continues during the entire discharge cycle. Discharge is fast and complete. No corners or pockets in drum. No "left overs" to contaminate succeeding batches. Insures improved quality of glass batches and greater production. Built in all standard sizes up to 112 cu. ft. Write for bulletin.

The T. L. SMITH CO.
2898 NORTH 32ND STREET
Milwaukee 10, Wis., U. S. A.

SMITH
T. L. SMITH CO. MILWAUKEE

Glass Batch MIXERS

ELECTRONIC PNEUMATIC CONTROL . . . .

(*Continued from page* 81)

lar function for the channel. Should the installation include a rear channel, a selector switch can be provided which, when depressed, causes the channel instrument to give a momentary indication of rear channel temperature. Upon release, the switch automatically reconnects the instrument to the controlling couple. This provides the operator with a convenient method of spot checking rear channel temperatures.

An outstanding feature of the Brown control system

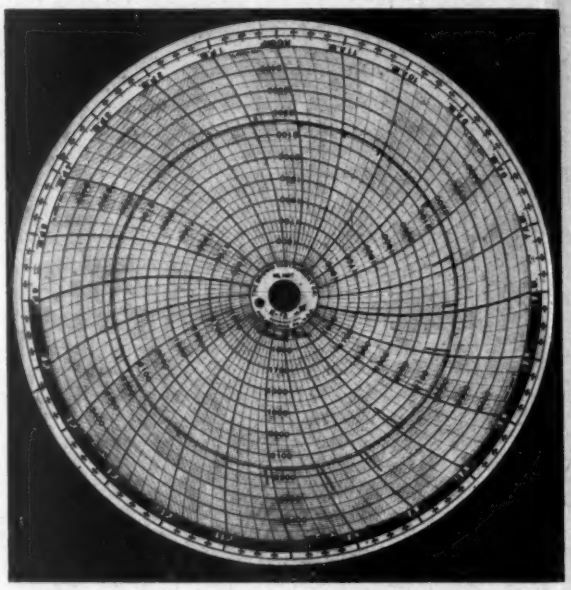

Fig. 3

is a signal light station which warns the operator when the control valve is approaching its operating limits, thus indicating that the temperature of the glass from the preceding zone is either too high or too low, and that some readjustment either of the instrument control setting or the "cooling wind" to the forehearth is required. For example, if the control valve from the spout instrument approaches its closed position, a red light warns the operator that the glass in the channel is at too high a temperature and that he should reduce the control setting on his channel instrument. A green signal would mean, of course, that the control setting on the channel instrument should be increased. A red signal from the channel instrument would indicate the need of an increased flow of cooling wind into the forehearth.

Although, at first, this signalling arrangement may appear simple, its importance should not be underrated because it facilitates continuous operation of the temperature control system by the machine operator.

Each instrument is provided with a manual control by-pass as an aid to the operator during shutdowns, or repair periods or when starting up a new feeder. This permits manual control from the instrument panel, and obviates the necessity for handling by-passes around the control valves.

Both instruments, complete with signal lights and control by-passes, are mounted on a heavy steel panelboard as shown in Figure 1. The diaphragm motor con-

trol valves in the combustion air line to the burners are illustrated in Figure 2.

Results of Field Tests. The complete control system has been thoroughly tested under typical production conditions in plants of national importance.

Under operating conditions, it was proven that this electronic instrument not only measured but completely corrected for temperature deviations regardless of their nature before a skilled operator was even aware that a change was taking place. Figure 3 is a reproduction of an actual chart clearly indicating the close control accomplished by this system.

Of greatest significance to the glass manufacturer is the confirmed fact that the control system makes it possible and practical to operate at lower stable temperatures, thus permitting higher machine speeds and a corresponding increase in gross pack.

The temperature is held under firm control continuously, a factor of prime importance during "job changes" when it is necessary that the feeder be stabilized at the new operating temperatures as soon as the molds are changed. On some job changes it has been observed that, under manual control, several hours have been required to stabilize the feeder temperature. With ElectroniK control this time has been reduced appreciably, in some instances, to as low as twenty minutes. This, of course, by materially reducing job change time, increases the gross output.

Rejects caused by variations in weight of bottles are held to a minimum under precise control, thereby increasing the per cent pack.

FRENCH ARTIST DISPLAYS STAINED GLASS PANELS

An exhibition of works of art by Jean Crotti, French artist, has been on display in New York City. M. Crotti has perfected a new medium of expression in art, namely, "Les Gemmaux"—the use of bits of colored glass.

The technique used is the joining of fragments of glass of all dimensions and colors by a transparent chemical substance which holds them in place. The glass is applied either by juxtaposition or by several layers to create the desired impression of brilliance and depth.

CORNING'S ONTARIO PLANT IN VOLUME PRODUCTION

The first heat-resistant glass ovenware to be manufactured in the Dominion of Canada is now being produced in volume at the Leaside, Ontario plant of the Corning Glass Works of Canada, Ltd. The Canadian company is a wholly-owned subsidiary of Corning Glass Works, Corning, New York.

It is expected, with full-scale production, that not only will requirements in Canada be supplied, but that some output will be available for export.

All manufacturing and warehousing operations are carried on in a single building, approximately 100,000 square feet in space. The plant is equipped with one tank, capable of melting 25 tons of glass daily, and two automatic presses on which a variety of Pyrex ovenware products will be made. At the present time, 150 men and women are employed at the Leaside plant, which is managed by H. C. Bates.

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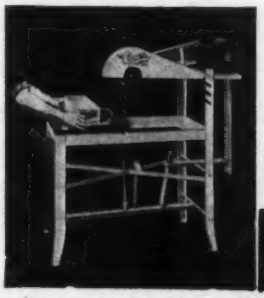

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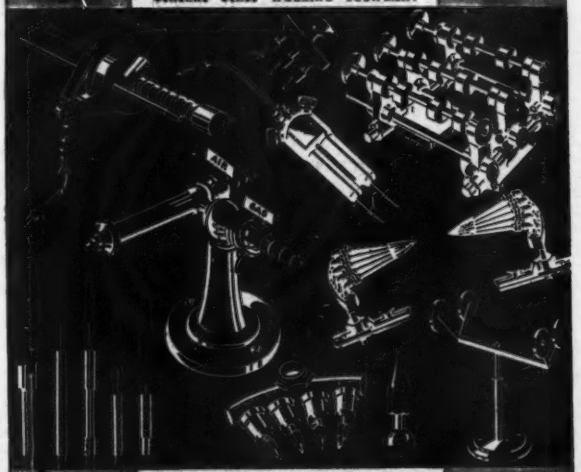

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SYLVANIA ELECTRIC APPOINTS STUART L. PARSONS

The appointment of Stuart L. Parsons as chief engineer for the Tungsten and Chemicals Division of Sylvania Electric Products Inc., at Towanda, Pa., has recently been announced by the company.

In this newly created position, Mr. Parsons will direct all divisional engineering, including research and equipment design for the production of tungsten salts and fluorescent powders for fluorescent lamps and television viewing tubes.

Joining the company's Physical Research Department in 1939, Mr. Parsons has specialized in the design and development of spectrographic equipment, mechanical components for radar, microwave tubes and equipment, wire drawing machines and special instruments for measuring the light output of fluorescent lamps and cathode ray tubes. He majored in physics at the University of Michigan and received his B.S. degree in 1938 and M.S. degree in 1939.

WYANDOTTE EXPANSION PROGRAM

A report has been made by Bert Cremers, Vice President in Charge of Sales of the Michigan Alkali Division of the Wyandotte Chemicals Corporation, on the progress which has been made in the company's $25,000,000 expansion program which was announced last summer.

Mr. Cremers reported as follows: *Calcium Carbonate Plant*: One of the three new units is already in production, a second is soon to roll and the buildings which house all three new units are completely enclosed. *Glycol*: Exteriors of the buildings are nearly completed and the greater part of the machinery is already on the job. Installation is proceeding at a rate that should bring production in the spring of this year. *Chlorine No. 3*: This plant is still in the foundation stage. Construction at this writing is "on time" with production scheduled for late 1947. *Synthetic Detergent*: The extra heavy foundation of this plant is well underway—78 foot piles being used instead of the 60 foot variety. Construction plans show completion is scheduled for late 1947. *Power House*: Steel for the addition to the North Plant power house is in place. Construction of the building and the equipment is progressing on schedule. *Alkalies*: A special leaflet, "Report Concerning Alkali Expansion Program of Wyandotte Chemicals Corporation," is soon due for distribution. Copies of the leaflet may be obtained on request.

PITTSBURGH SECTION FEBRUARY MEETING

The Pittsburgh Section of the American Ceramic Society will be host to Professor W. E. S. Turner at its February meeting.

Professor Turner, visiting professor of glass technology at the University of Illinois, will speak on the electric melting of glass.

LOUISIANA OFFERS TAX EXEMPTION TO ATTRACT NEW INDUSTRY

Recognizing the need for a workable means to interest new manufacturers to locate their plants within its borders and also increase the facilities of those firms already located in the state, Louisiana, through its Department of Commerce and Industry, has approved thus far in 1947 ad valorem tax exemption for nearly six million dollars worth of new construction at existing plants. In addition, the Board of Directors of the department at its last meeting took under advisement another twenty million dollars worth of exemption applications for "further study".

"This activity was recently granted under provisions of a constitutional amendment which received a favorable vote at the November general elections in Louisiana," D. Y. Smith, Director of the State Department announced. "Under terms of the law, our commerce and industry board, with the approval of the Governor, is authorized to grant exemptions for periods up to 10 years for new industries or additions and improvements to existing plants with the proviso that the approval of competitive industries in the same localities must be obtained."

Mr. Smith stressed the allegiance to the manufacturers and taxpayers who have already been in operation in Louisiana as, under the new amendment, no exemption may be given a new plant if it is to compete with an existing plant without approval of the existing plant.

DIAMOND ALKALI OBTAINS LOAN FOR EXPANSION

The Diamond Alkali Company has announced that final papers were recently signed on an $8,000,000 ten-year bank loan to help complete a $20,000,000 plant expansion and modernization program. The loan was negotiated through the Mellon National Bank & Trust Company and is to be shared in by five other banks.

The expansion program includes the construction of a $10,000,000 electrochemical plant already under way at Houston, Texas, and a $10,000,000 modernization and rehabilitation program of the company's main operations at Painesville, Ohio. These new and improved facilities, the company states, will permit an expansion of business volume of more than one-third over 1946 sales which, it is estimated, will exceed $30,000,000.

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HELP WANTED

WANTED—CERAMIC ENGINEER. Large middlewest glass factory wants Ceramic Engineer with experience in all glass decorating processes, petrography, refractories and lehrs. Position entails full responsibility for product development, process standardization and trouble shooting in these particular phases of manufacturing. Salary depends upon training and length of experience. Write details of training, experience, age, marital status, etc. Reply Box 52, c/o The Glass Industry, 55 West 42nd Street, New York 18, New York.

WANTED—CONSTRUCTION ENGINEER. Large midwestern manufacturer has an immediate opening for a construction engineer capable of engineering and supervising construction of steel buildings and designing plant layouts. Previous experience in the glass industry would prove helpful. Give personal details, education, experience and salary desired. Reply Box 53, c/o The Glass Industry, 55 West 42nd Street, New York 18, New York.

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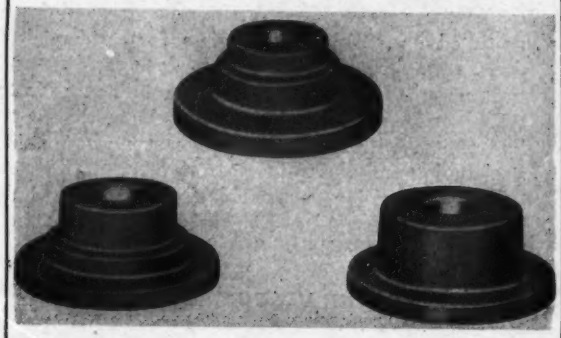
for
Guide Rings



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